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MARKET DISEASES OF FRUITS AND VEGETABLES

Citrus and Other Subtropical Fruits

BY

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Agricultural Research Administration

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UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION NO. 498

Washington, D. C. Issued June 1943

MARKET DISEASES OF FRUITS AND VEGETABLES: CITRUS AND OTHER SUBTROPICAL FRUITS[1]

By DEAN H. ROSE, *senior physiologist;* CHARLES BROOKS, formerly *principal pathologist;* C. O. BRATLEY, *pathologist;* and J. R. WINSTON, *senior horticulturist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Agricultural Research Administration*

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[1] This publication is the eighth in a series designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing, to facilitate the market inspection of these food products, and to prevent losses from such conditions. It is an extended revision and elaboration, with the addition of colored illustrations, of a preliminary (multigraphed) article, Handbook of Diseases of Fruits Under Market, Storage, and Transit Conditions, prepared in 1919 by Dean H. Rose and the late O. F. Burger for the use of the food-products inspectors of the Bureau of Agricultural Economics and never distributed to the public. The material for fruits is organized on the basis of the botanical families to which the plants belong, but no botanical system is followed in arranging these families. Practical considerations make it desirable to issue the material for the series in separate sections following somewhat in the order of the economic importance of the crops. The colored plates are reproduced from water-color paintings by the late L. C. C. Krieger, R. C. Steadman, Mary D. Arnold, and J. Marion Shull, of the Bureau of Plant Industry, under the direction of Dean H. Rose and D. F. Fisher, and from colored photographs prepared through the collaboration of Webster Bros., Chicago, Ill., under the direction of Dean H. Rose and the late O. F. Burger.

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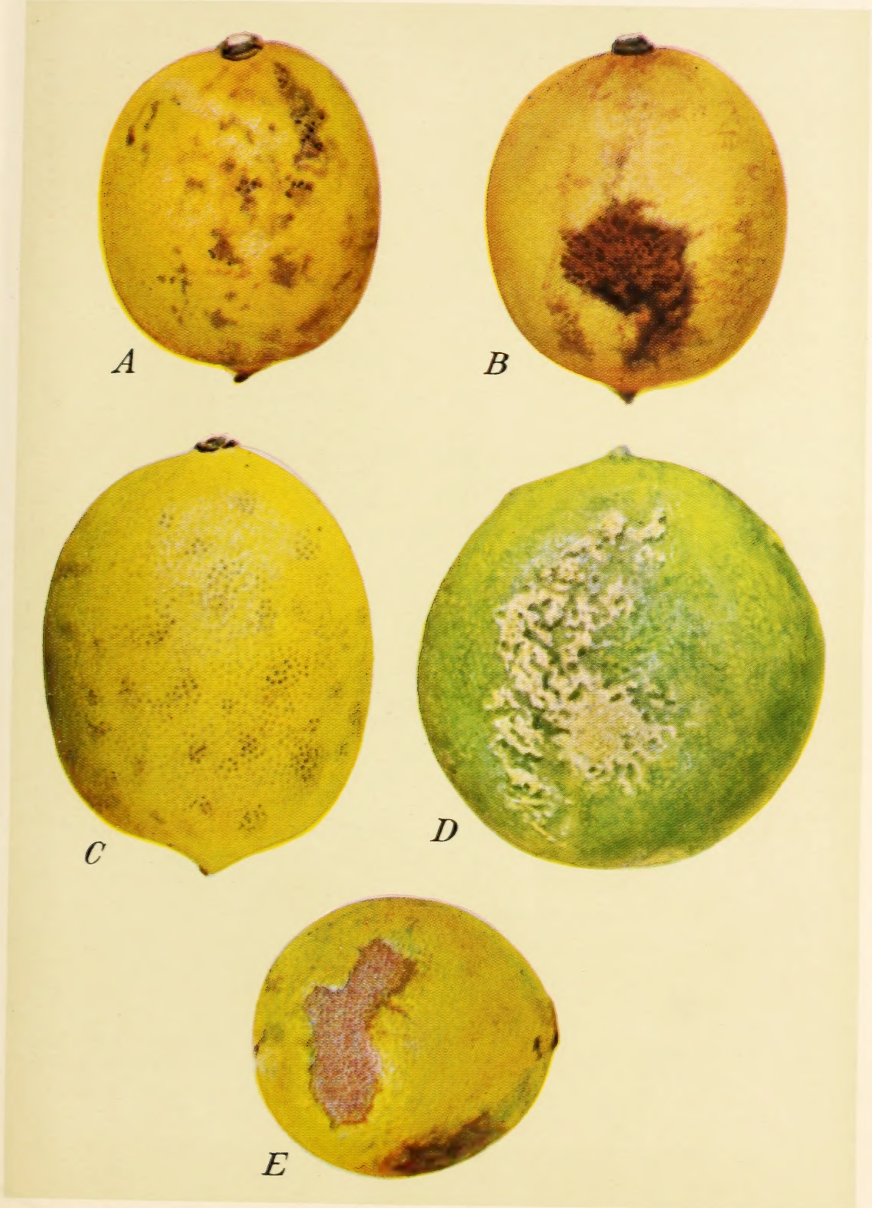
INTRODUCTION

Market diseases of fruits and vegetables are those that develop during the process of marketing. This process should be understood to include the harvesting, grading, and packing of the crop, its transportation to market, its storage at shipping point or at the market, and the various handling operations required to move it from the wholesale dealer to the retail store and the ultimate consumer. During any of these operations the product may be subjected to conditions that impair its appearance and food value and render it liable to attack by decay-producing organisms.

The fruits discussed in this publication, like all other fruits and vegetables, are susceptible to invasion by bacteria and fungi at bruises and skin breaks. Hence, it is of prime importance that they be handled as carefully as possible at all times. Clipper cuts, fingernail scratches, injuries caused by packing-house machinery, packing bruises, damage caused by rough handling in transit and on the market are all sources of danger, especially if the places where the fruit is packed, or stored, or offered for sale are not kept free of rotting fruit and other infectious material. These, as well as insect injuries, must all be considered by anyone attempting to judge the storage or shipping quality of the fruit or its ability to hold up well until it is consumed.

Temperature and humidity have a direct effect on the development of decay in fruits. They should have the critical attention of those who wish to ship or store fruits and of those who attempt to determine why a given lot, at any stage in the marketing process, shows decay or other deterioration. Too low temperature may freeze the fruit, or it may cause only chilling injury; subtropical fruits are particularly susceptible to such injury. Too high temperature favors decay and may



A, Anthracnose on lemon; *B*, red blotch on lemon; *C*, peteca on lemon; *D*, scab on orange; *E*, rind break-down on lime.

cause undesirable color changes. High humidity favors the growth of fungi, and low humidity causes loss in weight and possibly shriveling, especially if combined with high temperature. For all of these reasons, the management of storage rooms for citrus and other subtropical fruits and the choice of conditions under which to ship them to market, whether under refrigeration or under ventilation, are not likely to give the best results unless based on an intelligent use of all available information concerning the market diseases of those fruits.

CITRUS FRUITS

GRAPEFRUIT

AGING

(See Oranges, Aging, p. 18, and pl. 12, *A* and *B*.)

ANTHRACNOSE

(Associated with *Colletotrichum gloeosporioides* Penz.[2])

OCCURRENCE, SYMPTOMS, AND EFFECTS

Anthracnose is found on oranges, lemons, and grapefruit in groves and packing houses, as well as on the market and in storage (pl. 1, *A*). The anthracnose that the grower or shipper sees is rarely more than a pit or two and is seldom observed before midseason. If these pits are of long standing, a few *Colletotrichum* pustules, which rarely develop into decay in the field, may be found on the long-dead surface of the pits. Affected fruits on the market have scattered brown to black spots ranging in size from one-quarter to one-half inch or more in diameter. These spots undoubtedly started as bruised or otherwise injured areas, which were later invaded by the anthracnose fungus. On them there usually occur small black specks consisting of masses of spores and the mycelial pads (*Colletotrichum*) that produce them. The spores, which may be produced in such pads on rotten spots only one-half inch in diameter, are pink in mass at first; after exposure to the air they become discolored and in mass appear gray to black. The affected rind is rather tender, but there is no discoloration of the rag as in alternaria rot until late stages of the disease. Anthracnose, in advanced stages, penetrates deeply into the fruit and develops into an actual rot. If it occurs at the stem end the affected area is sunken and there is a definite line of demarcation between healthy and diseased tissue. Anthracnose is firmer and drier than stem-end rot, and the core region, if affected, is gray to black, fading through pink to the normal color.

CAUSAL FACTORS

Anthracnose is attributed to infection by the fungus *Colletotrichum gloeosporioides*. This fungus was at one time thought to be the cause of withertip of citrus but is now considered merely a secondary invader following the injuring of the young growth by other agencies; for example, drought, scab infection, or exanthema, or poor soil con-

[2] Perfect stage, *Glomerella cingulata* (Stonem.) Spauld. and V. Schrenk.

ditions and consequent malnutrition of the tree. Such dead growth furnishes a place where the fungus can live and grow, carries it over from one year to the next, and thus becomes a source from which the spores are spread to the fruit by wind, rain, or insects. As already noted, there is evidence that the fungus is often a secondary invader on the fruit, gaining entrance at pits or at other places weakened by other causes. The disease rarely develops until the fruit is quite ripe.

CONTROL MEASURES

Control of anthracnose depends on careful handling, the shipping of strong, first-quality fruit, and the avoidance of unduly long storage (longer than about 6 weeks). Temperatures in transit below 50° F. should prevent development of the rot during the usual transit period. It is important to keep the trees well pruned and to use cultural practices that will maintain the trees in good healthy condition, thereby reducing excessive accumulation of dead twigs that may harbor the fungus.

(See *32*, *43*, *96*, *112*.)[3]

BLACK ROT (ALTERNARIA ROT)

(See Oranges, Black Rot (Alternaria Rot), p. 19, and pl. 13, *C*.)

BLUE MOLD AND GREEN MOLD ROTS

(See Oranges, Blue Mold and Green Mold Rots, p. 19, and pl. 6, *B* and *C*.)

BROWN STAIN (SCALD)

(See Oranges, Brown Stain (Scald), p. 21, and pl. 12, *E*.)

CITRUS RUST MITE RUSSETING

(See Oranges, Citrus Rust Mite Russeting, p. 22, and pl. 5, *B*.)

COLORING-ROOM INJURY

(See Oranges, Coloring-room Injury, p. 23, and pl. 12, *D*.)

EXANTHEMA (AMMONIATION)

(See Oranges, Exanthema (Ammoniation), p. 24, and pl. 15, *A*.)

FREEZING INJURY

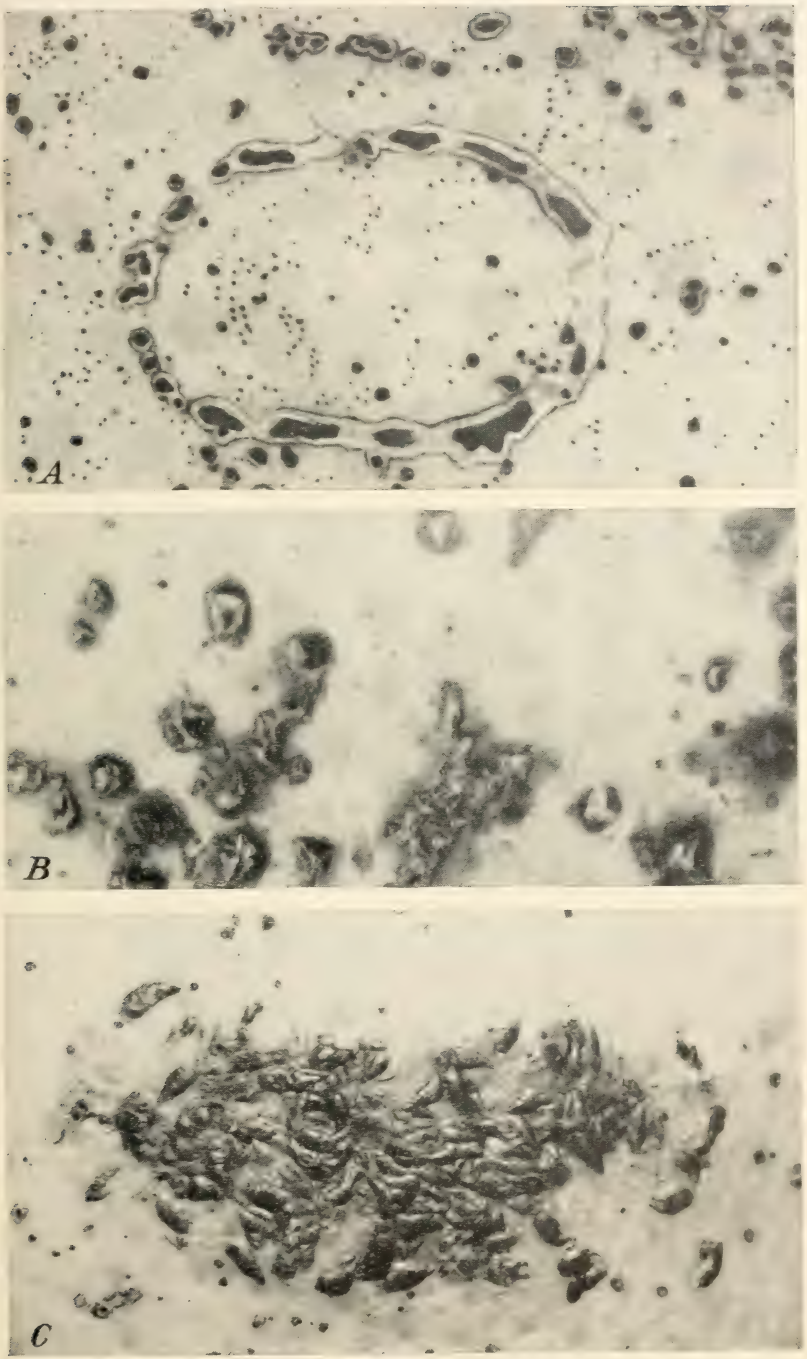
(See Oranges, Freezing Injury, p. 27, and pl. 16, *A–C*.)

GUMMING

Among citrus fruits, gumming, not connected with exanthema, has been observed in grapefruit and oranges at injuries, such as thorn punctures, that apparently had occurred several weeks before the fruit was picked. The masses of gum are of an amber color and are always

[3] Italic numbers in parentheses refer to Literature Cited, p. 51.

Melanose on grapefruit: *A*, Usual type; *B*, "mud-cake" type.



A Melanose on grapefruit, showing cracking around lesions; *B*, exanthema on orange, showing cracking across pustules; *C*, purple scale on grapefruit

Pitting on grapefruit: *A*, Large type; *B*, small type.

found in, or on the edge of, the wounds from which the gum exudes. They vary somewhat in size but are rarely more than three-eighths of an inch in diameter.

HEAT INJURY

(See Oranges, Heat Injury, p. 29, and pl. 12, *C*.)

MELANOSE

(*Phomopsis citri* Fawc.,[4] which also causes stem-end rot)

Melanose occurs in all citrus-growing regions of the United States and is also found in many other parts of the world where *Citrus* is grown. In the United States it is probably of greatest importance in Florida and the other Gulf States. Leaves, young twigs, and fruit of various plants belonging to the genus *Citrus* are affected. On the fruit the disease can be recognized as small, brown, raised spots produced by the causal fungus attacking and killing a few epidermal cells of the rind (pl. 2, *A*). In these spots the fungus usually dies long before the fruit matures. In most cases the individual spots are about the size of a pinhead, although they may coalesce to form rather large scablike patches known as "mud-cake" melanose (pl. 2, *B*). Sometimes the spots appear in a kind of tearstaining, but they can readily be distinguished from the blemish of this name, caused by citrus rust mites, by their brown, glazed appearance and by the fact that they are slightly elevated above the surface of the surrounding healthy skin. Melanose tearstaining is much more common than that caused by citrus rust mites. Melanose can be distinguished from the pimple stage of exanthema (ammoniation) by the facts that the pimples of melanose are dark brown surrounded by gray and when examined under a hand lens they are seen to be cracked away from the healthy skin around them (pl. 3, *A*); those of exanthema are dark reddish brown and, if they are cracked at all, the cracks appear across the top (pl. 3, *B*).

Melanose does not spread in transit. It is of importance merely as a blemish, and its chief effect is to cause the fruit to grade lower than it would if melanose were not present.

In the average season in Florida the disease is readily controlled by one or two applications of standard 3–3–50 bordeaux mixture. Cutting out dead wood is an aid to control.

(See *5*, *43*, *96*, *98*, *135*, *142*.)

OIL SPOTTING (OLEOCELLOSIS)

(See Lemons, Oil Spotting (Oleocellosis), p. 14, and pl. 11, *A* and *B*.)

PITTING

Pitting of citrus fruits, as its name indicates, consists of abruptly sunken spots in the rind. It is sometimes called pox, but the use of this term is undesirable. The spots are not discolored at first, but later they may become slightly pink on grapefruit and eventually brown on both grapefruit and oranges (pl. 4, *A*). Pits on Pineapple

[4] The perfect stage, *Diaporthe citri* Wolf, has been reduced by Wehmeyer (*134*) to synonymy with D. *medusaca* Nitschke.

oranges are likely to be larger than on other varieties. They coalesce into large areas, sometimes an inch in diameter. Early and midseason oranges are more susceptible to pitting than are the late-ripening varieties, the Pineapple variety being the most susceptible. Smooth-skinned fruit is more likely to develop pitting than is coarse fruit, and those of small sizes are more susceptible than large ones.

IN THE FIELD

Pitting, as seen in the field and packing houses, differs considerably from that which develops in storage or on the market. Under field conditions pits on grapefruit are rarely as much as an inch in diameter and rarely coalesce, and the affected areas remain firm. Pits rarely lead to invasion by *Penicillium* or the stem-end rot fungi before harvest.

ON THE MARKET OR IN STORAGE

Pits found on fruit on the market or in storage are usually one-fourth to one-half inch in diameter (pl. 4, *A*) where they occur singly, but they may enlarge to 1½ to 2 inches or more where several pits coalesce. They are usually larger on grapefruit than on oranges, although on grapefruit held at 32° F. they are typically less than one-fourth inch in diameter (pl. 4, *B*). Softening often occurs underneath the pits and may lead to invasion by blue mold, the withertip fungus, or the stem-end rot fungi. The pulp beneath large pitted areas usually has a tainted taste. In affected areas of the rind the oil glands are particularly noticeable in early stages of the disease, especially on oranges, because in such places they are raised and slightly darker than the tissues surrounding them. In old pits these glands are definitely sunken.

As noted above, the disease may occur on fruit at time of packing, or it may develop in transit, particularly on Pineapple oranges and on small-sized fruit of Parson Brown, Hamlin, and other midseason varieties. Generally it does not develop until after a storage period of 4 to 6 weeks when it is often accompanied by aging or shriveling of the rind around the stem. It usually is worse at 36° to 40° F. than at either higher or lower temperatures.

(See *23*, *24*, *43*, *52*, *57*, *58*, *59*, *61*, *62*, *89*, *90*, *91*, *109*, *110*, *111*, *112*, *119*.)

PURPLE SCALE

(*Lepidosaphes beckii* (Newm.))

The purple scale is essentially a citrus fruit pest, although its attack is not restricted to plants of that family. The adult female averages one-tenth inch in length. The scale covering, in general color, is a brownish purple, and its shape resembles that of an oyster shell (pl. 3, *C*).

Injury to the fruit is due directly to the feeding of the insect, which, if it occurs on ripe fruit, has a tendency to delay coloring. The scales are so firmly attached to the fruit that they are removed with great difficulty by the washing machinery and as a result are very often seen on fruit on the market.

(See *93*, *94*, *100*, *131*, *132*, *146*.)

SCAB

(*Sphaceloma fawcettii* Jenkins[5])

Scab is found chiefly on Temple oranges and on grapefruit. It attacks tangerines to a lesser degree and is sometimes found affecting King oranges, Tahiti (Persian) limes, and some tangelos. It is extremely rare on sweet oranges and kumquats. Lemons are susceptible but are generally grown where climatic conditions prevent scab development. The disease occurs on fruit in Florida and Texas and in the West Indies but has not been reported from California. It is believed to have been introduced into the United States on Satsuma orange trees from Japan and is widely distributed over the world in citrus-growing countries where climatic conditions are favorable to its development. On the fruit the earliest symptoms are small raised areas in the rind, which are whitish at first but later assume a pinkish or tan color. Scab occurs on leaves, twigs, and fruits but attacks these parts only while they are young. On all three it starts in much the same way, namely, as small pale-yellow to orange-colored elevated spots, which as they grow older become irregular scabby areas or warty protuberances ranging in color from drab to dark olive gray. These protuberances may be single or they may coalesce to form large raised patches of gray or tan-colored scab. Fruits severely infected while young may become misshapen because of excessive development of the warty outgrowths. On mature grapefruit the skin around the scabby areas tends to remain green.

On the fruit, the disease affects only the skin but makes the fruit unsightly and therefore less valuable on the market. Since infection takes place only when the fruit is small there is no danger of new infection in transit or storage. Areas affected by scab are not invaded by other fungi.

As scab is a field disease, it can be controlled by spraying with bordeaux mixture. It is also desirable to cut out and burn all infected sour orange and rough lemon sprouts from rootstocks of grove trees.

(See *21*, *37*, *40*, *43*, *69*, *87*, *96*, *99*, *136*, *137*.)

SCLEROTIUM ROT

(See Oranges, Sclerotium Rot, p. 31.)

SEPTORIA SPOT AND STAIN

(See Oranges, Septoria Spot and Stain, p. 31, and pl. 15, *B*.)

SPRAY INJURY

(See Oranges, Spray Injury, p. 32, and pls. 6, *D*, and 11, *C*–*E*.)

STEM-END ROT

(*Phomopsis citri* Fawc.[6] and *Diplodia natalensis* Pole-Evans[7])

OCCURRENCE, SYMPTOMS, AND EFFECTS

Stem-end rot caused by *Phomopsis citri* and *Diplodia natalensis* is a destructive and widely distributed disease of citrus fruit in the Gulf

[5] Perfect stage, *Elsinoë fawcetti* Bitanc. and Jenkins.
[6] See footnote 4.
[7] Perfect stage, *Physalospora rhodina* (Cke.) Berk. and Cke.

States, the West Indies, and other citrus-growing regions of the world (pls. 5, *A*, and 6, *A*). Diplodia rot is occasionally found in California lemons, as is also a less destructive rot caused by *Phomopsis californica* Fawc. However, both of these are so rare on California fruit as to be of decidedly minor importance, both in the grove and on the market.

Typical stem-end rot, whether caused by *Phomopsis* or *Diplodia*, is characterized by a softening of the rind and underlying pulp, which begins almost invariably at the stem end (pl. 5, *A*), although it sometimes begins at injuries on the side; at ordinary temperatures it may extend an inch a day so that only 4 or 5 days are required to rot the fruit completely. Neither form of the rot shows much discoloration in the early stages. In late stages the affected rind turns tan color to brown and sometimes even black. Both forms progress rapidly down the spongy, circular axis, usually reaching the blossom end sooner by this route than through the surface rind; they sometimes show a marked development in the rind along the lines that mark the divisions between the segments of the pulp. Affected fruits do not shrivel or lose their shape unless subjected to pressure, and they ordinarily show no fungus growth on the surface. The taste is flat and somewhat bitter, and affected tissues have an unpleasant, rancid odor. Immature citrus fruit is very resistant to stem-end rot, whereas dead-ripe fruit is very susceptible.

CAUSAL FACTORS

The two commoner stem-end rot fungi flourish and form spores in or on dead citrus bark. *Phomopsis* usually develops most abundantly in recently killed bark of very small twigs and fruit stems; *Diplodia* occurs most frequently on larger twigs and limbs. During periods of rainy weather the spore crops are produced and disseminated. The first infection produced on the fruit involves some portion of the stem button at some time during the growing season; soon after the fruit is clipped from the tree there is active growth of the fungus from the button into the rind and flesh.

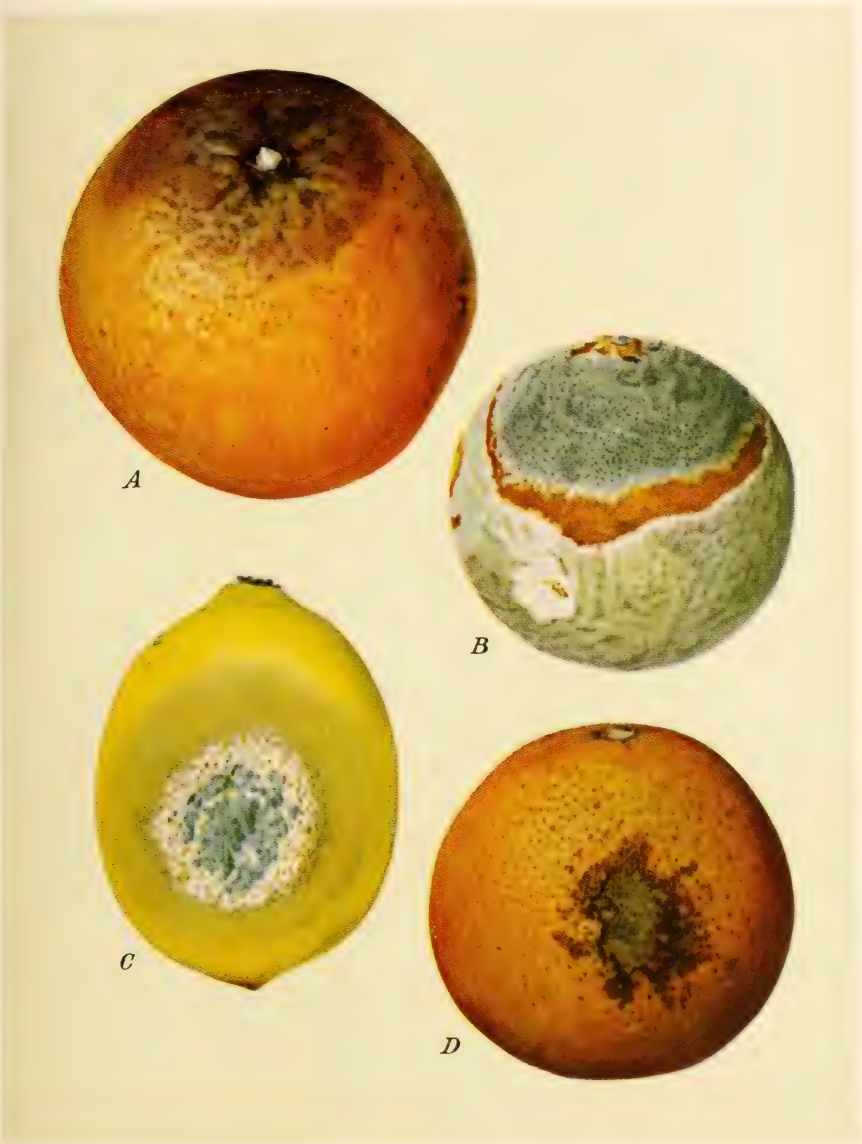
Phomopsis and diplodia rots may occur in the same lot of fruit, but *Phomopsis* is more frequent in Florida fruit and *Diplodia* in fruit from Puerto Rico and Cuba. During the cooler months in Florida when no gassing is used, *Phomopsis* occurs more frequently than *Diplodia*. In summer *Diplodia* predominates even on ungassed fruit. When both rots occur, an important factor in determining which will predominate is temperature; the optimum temperature for growth of *Diplodia* is about 86° F. and for *Phomopsis* about 73°.

Under certain conditions stem-end rot may attack fruits on the tree, causing them to drop. Usually, however, it does not develop to a serious extent in the grove but may become severe by the time the fruit reaches the retailer or the consumer. It is impossible to distinguish and cull out fruits that may later develop stem-end rot, since at ordinary temperatures the crest of the rot, in fruit packed as being perfectly sound, is not reached until 10 to 20 days after packing.

CONTROL MEASURES

Practical prevention of excessive loss from stem-end rot depends on several factors. One of the most important of these is prompt marketing and consumption of the fruit with as continuous cooling to 50° F. or slightly lower as may be practicable. Temperatures of 40° to

A, Stem-end rot on grapefruit; *B*, citrus rust mite injury on grapefruit.



A, Stem-end rot on orange; *B*, blue mold and green mold rots on orange; *C*, blue mold rot on lemon; *D*, sulfur-spray injury on orange.

45° are as necessary for control of stem-end rots in transit as for green mold and blue mold rots. In storage, 32° to 34° is desirable for all of these rots.

Marked reduction in the percentage of phomopsis and diplodia rots after the fruit is harvested has been obtained by treating the fruit with a borax solution before it is packed. The treatment consists in submerging the fruit in an 8- to 10-percent solution of borax (*139*) and then allowing it to dry. The borax residue should be left on the fruit for several hours before it is washed. Heating the solution to about 120° is necessary to keep the borax in solution and make it more effective.

Disbuttoning is also beneficial, because it removes the source from which infection spreads into otherwise sound fruit. Pulling grapefruit instead of removing it with clippers is beneficial for the same reason and is now extensively practiced in Florida. Oranges cannot safely be harvested by pulling because of the danger that the rind around the button will be plugged (torn).

Pruning out dead limbs and twigs to diminish the sources of infection is a helpful measure and has the further advantage that it tends to decrease the melanose spotting of immature fruits caused by *Phomopsis citri*.

(See *6*, *10*, *23*, *27*, *28*, *38*, *41*, *42*, *43*, *52*, *61*, *64*, *96*, *109*, *110*, *111*, *112*, *138*, *139*, *140*, *141*, *143*.)

STYLAR-END ROT

(See Oranges, Stylar-end Rot, p. 32, and pl. 13, *E*.)

SUNBURN

There are sometimes seen, on grapefruit and oranges, large areas that are pitted all over, hard, and much yellower than the rest of the fruit surface. The pits are very small and apparently have resulted from collapse of the oil cells. In the lots of fruit that show various degrees of more severe injury the stages seen may be yellow hard spots, or similar spots with a brown patch near the center or with a gray patch at the center surrounded by a brown zone, the gray patch (½ to 1½ inches in diameter) sometimes with either very small black specks (the fruiting bodies of some fungus) or a black velvety fungus growth over the whole surface. Occasionally the gray area becomes softened and may be encircled by a brown to dull salmon-colored diseased zone. What appears to be the final stage consists of a large, softened diseased area, which is a dull salmon color all over and is surrounded by a hard, yellow, pitted zone.

The occurrence of spotting of this kind, known as sunburn, is probably due to injury by hot sunshine acting alone or in combination with drops or films of spray mixtures adhering to the fruit, and to subsequent infection by one or the other of two stem-rot fungi (*Phomopsis* and *Diplodia*) or more probably by *Colletotrichum*. It is possible that the spotting sometimes results from severe drenching of the fruit with a spray mixture, without any contributory action by sunshine. (See also Oranges, Spray Injury, p. 32.)

The later stages, showing rather soft decay, would not ordinarily be found in packed fruit on the market unless the grading and packing had been carelessly done.

TEARSTAINING

Tearstaining or streaking may be due to several different causes but is due chiefly to the melanose fungus (p. 5) and the citrus rust mite (p. 22) and, rarely, *Septoria* and the anthracnose fungus (*Colletotrichum*). Melanose tearstaining is caused by the melanose fungus (*Phomopsis citri*) and occurs in the form of streaks where water from rain or dew has run down over the side of the fruit, carrying spores of the fungus with it and resulting eventually in infection and the development of the typical pimples in the rind. It is much more common than that caused by citrus rust mites.

Citrus rust mite tearstaining occurs as brown streaks on the fruit, the discoloration occurring solidly rather than as numerous small discolored spots as in melanose tearstaining. The surface of the rind in citrus rust mite tearstaining is fairly smooth, whereas in the melanose form it is likely to be somewhat rough.

In California a staining or streaking similar to that caused by the citrus rust mite may be brought about by a light frost followed by sunshine, the injury probably being caused by oil liberated from the rind, causing streaks of discoloration on the rind as it runs down over the side of the fruit.

Tearstaining of lemons caused by the anthracnose fungus is known to occur in California but is of relatively little importance. Anthracnose tearstaining is rare in Florida and as observed there is indistinguishable from the staining caused by the citrus rust mite.

(See *43*, *47*, *98*, *100*, *135*.)

WATERY BREAK-DOWN

Citrus fruits affected with watery break-down are soft and spongy and have a soaked appearance resembling that of fruit that has been frozen. The flesh as well as the rind may be softened. In fruit in this condition the carpels are loosely attached to the inner part of the rind, and when a section of the rind is pressed, a watery substance oozes freely from the albedo.

Watery break-down is a low-temperature disease found most often on fruit stored at temperatures below 40° F. However, even at 32° it does not develop until after several weeks of storage. Affected fruits have a disagreeable odor of fermentation that is particularly noticeable when they warm up after removal from storage.

(See *23*, *119*, *125*.)

LEMONS

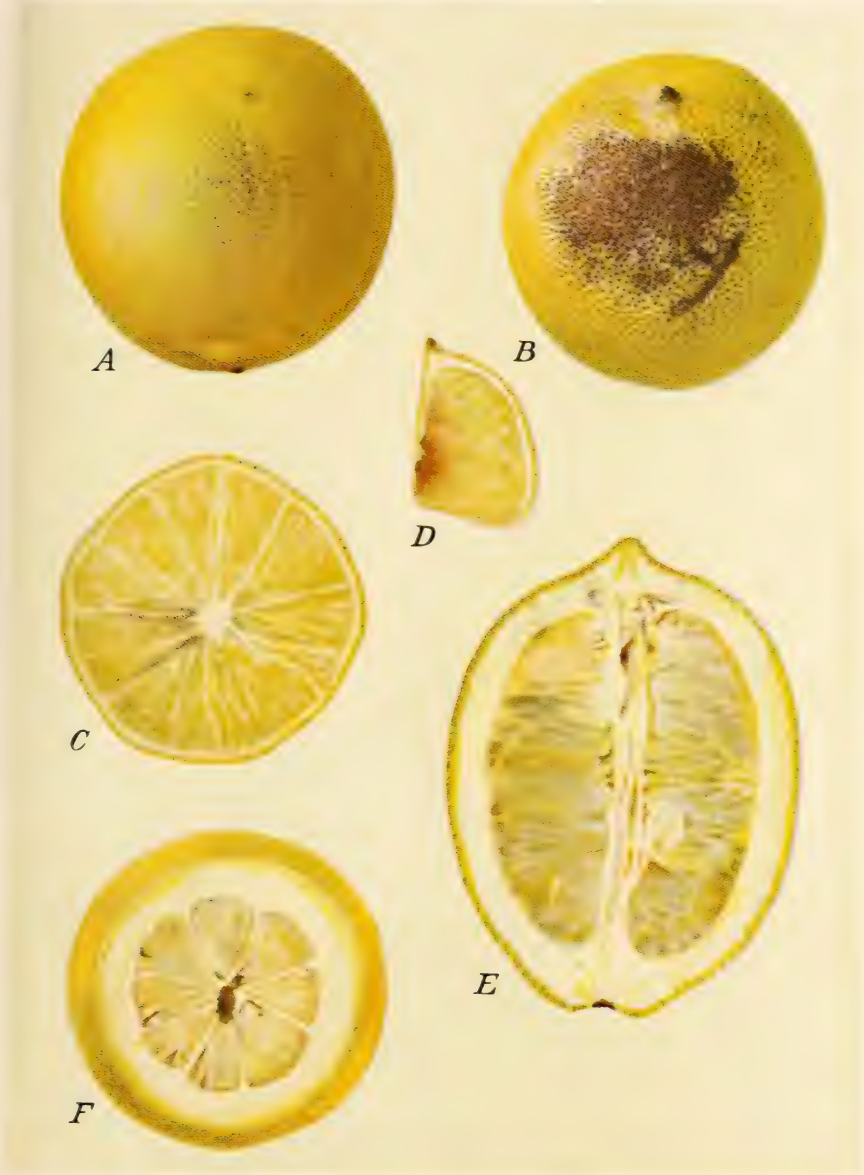
ALBEDO BROWNING

Albedo browning is a discoloration of the white, spongy, inner part of the rind. The disease may be evident externally only as a slight darkening of the rind due to the discolored inner tissue showing through the surface layer (pl. 7, *A* and *B*). It is believed to be increased by low temperature storage (32° F.) and poor ventilation.

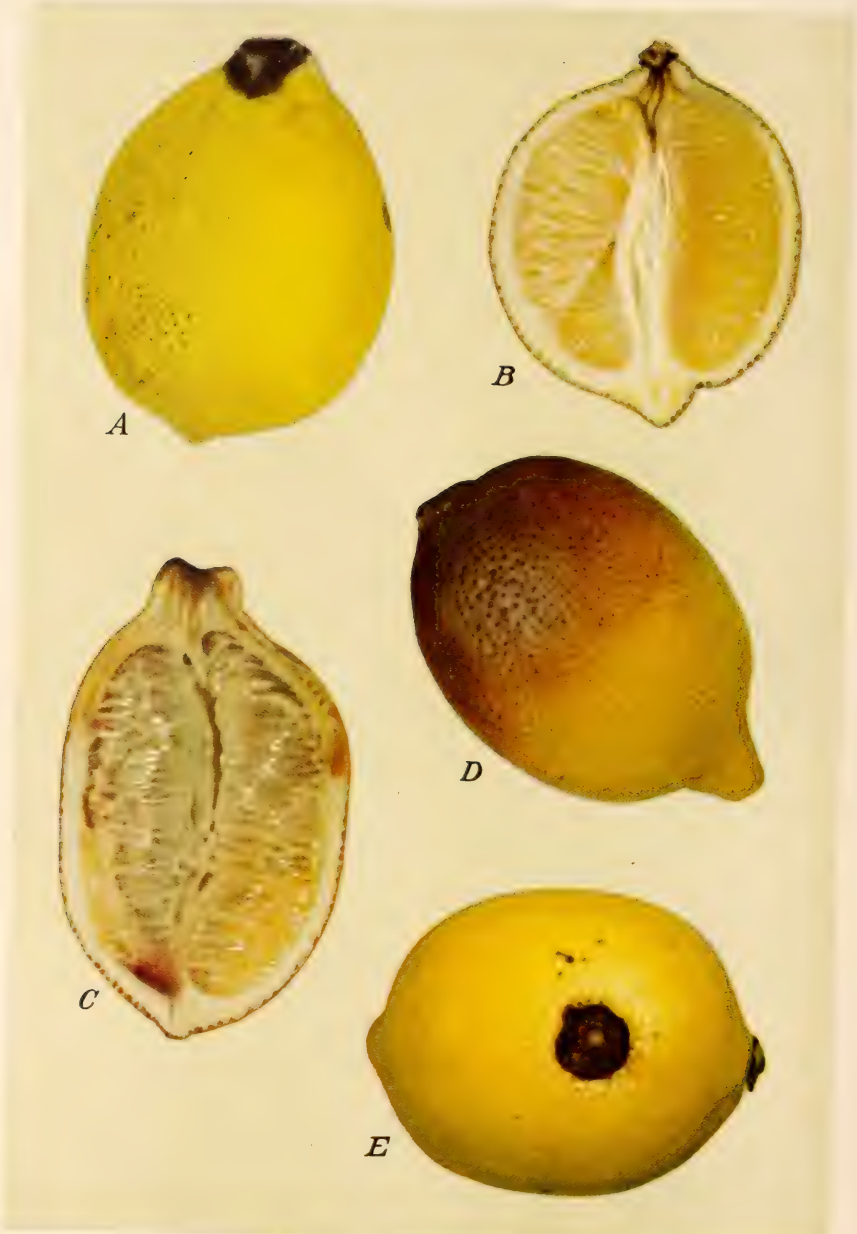
ALTERNARIA ROT

(*Alternaria citri* Ell. and Pierce)

Alternaria rot has been found in all lemon-growing districts and in some seasons is common on the market on both Italian and Califor-



A and *B*, Albedo browning on lemon; *C* and *D*, membranous stain on lemon; *E* and *F*, internal decline on lemon.



A–C, Alternaria rot on lemon: *A*, On rind, around the button; *B*, longitudinal section showing early stage; *C*, longitudinal section showing late stage. *D*, Brown rot on lemon. *E*, Black pit on lemon.

nia lemons, particularly on those that have been in storage for some time before shipping or that are held for several weeks at the receiving point before being put on the retail market. Fruits that are overripe or have been weakened by orchard freezing, drought, or internal decline are very susceptible. Under present conditions alternaria rot is second in importance only to the rots caused by blue and green molds.

The decay begins almost invariably at the stem end, the fungus gaining entrance through the button (pl. 8, *A*). For the most part, it affects the central core and the stem end, but it may also occur purely as a stem-end rot with no faster development in the core than elsewhere. In the commoner type of decay the button first browns, and then a slowly developing discoloration proceeds along the central axis (pl. 8, *B* and *C*) and to some extent in the inner tissues of the rind, without at first visibly affecting the exterior. Once established in the fruit the fungus develops rapidly, breaking down the rag until this becomes a slimy leaden-brown mass, and then continues to grow outward through the rind. When it reaches the surface, dark-colored diseased areas one-eighth to one-fourth inch or more in diameter become apparent. These increase rapidly in size and become a deeper leaden brown as they enlarge, until the entire rind is broken down into a slimy, dull-brown mass similar to the decayed rag.

Weak fruit shows a greater susceptibility to alternaria rot than fruit that is physiologically strong. A good indication of the latter condition is the fresh green appearance of the buttons. Prolonged exposure to high temperatures used for ethylene treatment or curing favors the development of the disease. At a temperature of 55° F. or lower the progress of the causal organism is slow. Fruit that is left on the trees until it has full lemon color is more susceptible than that which is picked in the green or "silver" stage.

(See *12*, *14*, *42*, *43*, *49*.)

ANTHRACNOSE

(See Grapefruit, Anthracnose, p. 3, and pl. 1, *A*.)

BLACK PIT

(*Phytomonas syringae* (Van Hall) Bergey et al.)

Black pit of lemons is caused by the bacterium *Phytomonas syringae*. It occasionally occurs on oranges as well as on lemons and is found in most of the citrus-growing regions of the world, yet it is of relatively minor importance in the United States. It is seen only rarely on the market.

On lemons black pit produces sunken spots or pits that usually range from one-fourth to one-half inch in diameter (pl. 8, *E*). The collapsed area is first light brown, then dark brown, and finally black. Under California conditions the disease is most likely to be troublesome after heavy winter winds with rain. No special control measures have been developed.

(See *42*, *43*, *45*, *106*.)

BLUE MOLD AND GREEN MOLD ROTS

(See Oranges, Blue Mold and Green Mold Rots, p. 19, and pl. 6, *B* and *C*.)

BROWN ROT

(*Phytophthora citrophthora* (Sm. and Sm.) Leon. *P. parasitica* Dast., *P. palmivora* Butl., *P. syringae* Kleb., and *P. cactorum* (Leb. and Cohn) Schroet.)

Brown rot is found on lemons in groves, packing houses, and in storage, and it occurs in all the principal citrus-growing countries of the world. The rot is first evident as a slight discoloration of the rind and in mature lemons the affected tissue soon takes on various shades of drab and brown (pl. 8, *D*). The juice of the lemon is too acid for the organism so that the growth is likely to be confined to the rind, the central cylinder, and the division tissues between the segments of the flesh. The fruit does not soften rapidly. There is usually no evidence of mold on the surface, but under very humid conditions a delicate, white surface mold appears. The disease can be identified by the rather penetrating, aromatic, rancid odor of affected tissues.

The causal fungi live in the soil and much of the infection that they produce in the orchard results from the splashing of their motile swimming spores onto leaves and fruit during rains. If winds accompany or follow immediately after the rain, the spores may be carried high into the tree and cause infection 20 or 30 feet from the ground. Infected fruit may carry spores into the washing tank and thus result in a development of the disease later in storage.

As a preventive of infection in the packing house copper sulfate or potassium permanganate is sometimes added to the wash water at the rate of 1½ pounds to 1,000 gallons. Sodium carbonate and trisodium phosphate have been found effective when used in 1¼-percent solutions. A 5- to 7-percent solution of borax has not been found so satisfactory unless the water is heated. The treatment most commonly used at present for the control of this rot consists in submerging the fruit for 2 minutes in water heated to 115° F. or for 1 minute in water heated to 120°. Although the different species of *Phytophthora* do not have exactly the same temperature response they are all greatly delayed in growth and rotting effect at a temperature of 50°.

(See *11*, *42*, *43*, *46*, *108*.)

COTTONY ROT

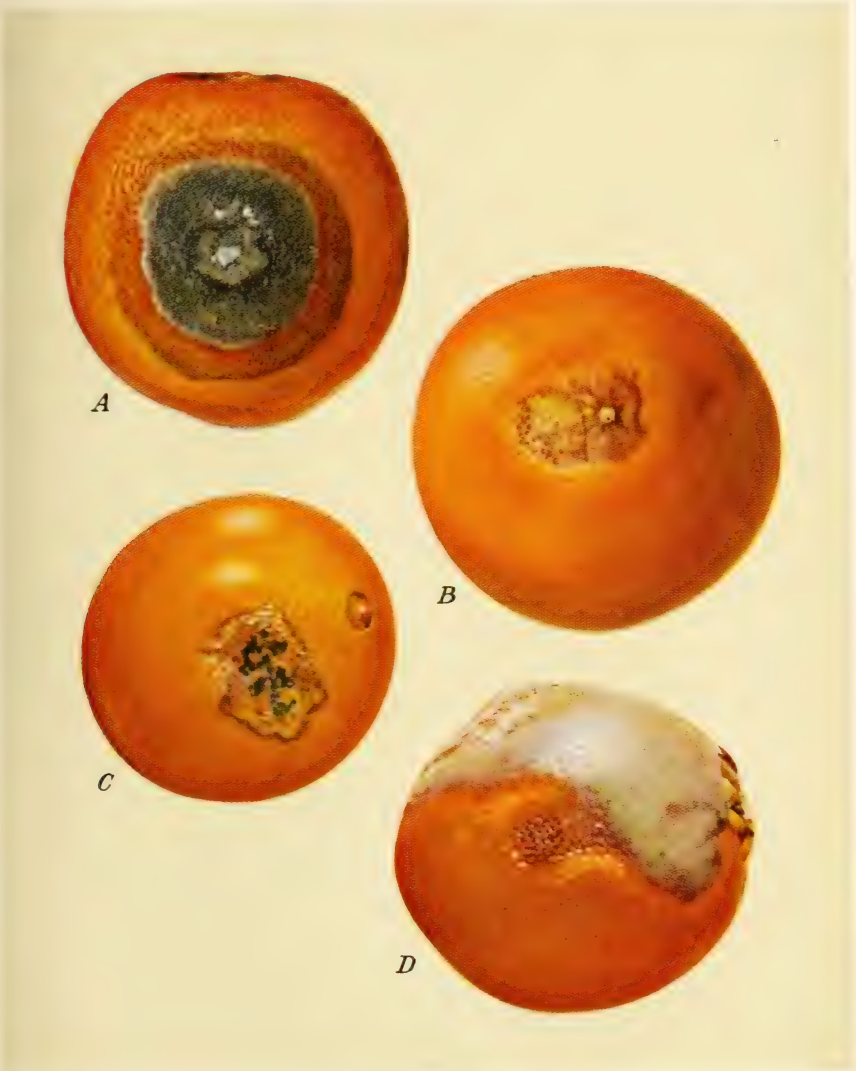
(*Sclerotinia sclerotiorum* (Lib.) DBy.)

Cottony rot, caused by the fungus *Sclerotinia sclerotiorum*, is widely distributed in many of the citrus-growing regions of the world. It is found chiefly in lemons.

Affected fruit softens slowly, and the skin is at first leathery and pliable. In a dry atmosphere the color of the decayed area on a mature lemon becomes yellowish brown or greenish brown. In a moist atmosphere the fruit is rapidly covered with a white, cottony growth of mycelium that gives the outstanding distinguishing characteristic of the decay (pl. 9). Cheesy, black sclerotial bodies are later developed in the fungus mat.

Cottony rot is a rapidly spreading contact decay that may attack both green and mature fruit and cause heavy losses in the packing house or in storage. Moderate temperatures, high humidity, and stagnant air are favorable to its development. However, the causal

Cottony rot on lemon



A, Gray mold rot on orange. *B–D*, Water spot on navel oranges: *B*, At navel; *C*, on side of fruit, with secondary infection by a rot fungus; *D*, advanced stage of rot following water spot (commonly called water rot).

fungus is able to grow to some extent even at temperatures close to freezing and hence may cause damage in transit at the temperatures ordinarily provided for lemon shipments. Careful handling, packing-house sanitation, and washing the fruit in hot water, as for brown rot (p. 12), are recommended preventives.

(See *42*, *43*, *95*, *104*.)

FREEZING INJURY

(See Oranges, Freezing Injury, p. 27, and pl. 16, *A–C*.)

FUMIGATION INJURY

(See Oranges, Fumigation Injury, p. 28, and pl. 14, *C* and *D*.)

GRAY MOLD ROT

(*Botrytis cinerea* Pers.)

Gray mold rot, caused by the fungus *Botrytis cinerea*, has been reported from most of the important citrus regions of the world, but it is more common on lemons than on other citrus fruits.

The early stage of the decay may closely resemble cottony rot, but distinguishing characteristics are soon evident. The color of the decayed area is darker, passing from cinnamon brown to various shades of dark brown, and the mycelium that develops in moist air is gray instead of cottony white (pl. 10, *A*). A characteristic feature of the mycelium is the gray, granular-appearing spore tufts.

The rot may be found in the orchard but is most common in transit, in storage, or on the market. Control measures are similar to those for brown rot (p. 12).

(See *42*, *43*.)

INTERNAL DECLINE (ENDOXEROSIS)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Internal decline is known at present only in California lemons. It is more prevalent in the drier interior valleys than in the more humid districts near the coast. All the varieties grown in California are susceptible.

Internal decline is a breaking down or drying out of the tissues near the stylar end of the lemon (pl. 7, *E* and *F*). Affected tissues become pinkish or brownish in color. One-fifth to one-half of the interior of the lemon may be involved in extreme cases, but such fruits are practically certain to be culled out in packing operations. The disease is not known to develop after harvest, but it renders the fruit more susceptible to decay, especially that caused by *Alternaria* (*43*).

On green fruit the presence of the disease may be indicated externally by a loss of luster or the development of a yellow color at the stylar end while the rest of the surface is still a normal green. On either "silver" or mature fruit it is difficult to detect internal decline from outward appearance, especially in mild cases. Sometimes there are a more intensive coloring of the rind at the stylar end and a collapse of the tissues at the base of the nipple that causes it to bend over.

CAUSAL FACTORS

Experimental evidence indicates that one of the causes of internal decline is the withdrawal of water from the fruits by the leaves during periods of low humidity and high temperature. Freezing appears to be another cause, since it was noted during the picking season of 1922 that fruit from trees that had been frozen the previous winter showed a great deal of the decline, whereas fruit from trees damaged only slightly by freezing or not at all showed very little.

CONTROL MEASURES

The following suggestions have been made for preventing internal decline: (1) Get as much humus as possible into the soil to aid in aeration and water penetration and to increase the water-holding capacity of the soil; (2) irrigate to maintain optimum soil moisture conditions; and (3) use windbreaks to overcome some of the effect of drying winds.

(See *1*, *13*, *15*, *16*, *17*, *24*, *42*, *43*.)

MEMBRANOUS STAIN

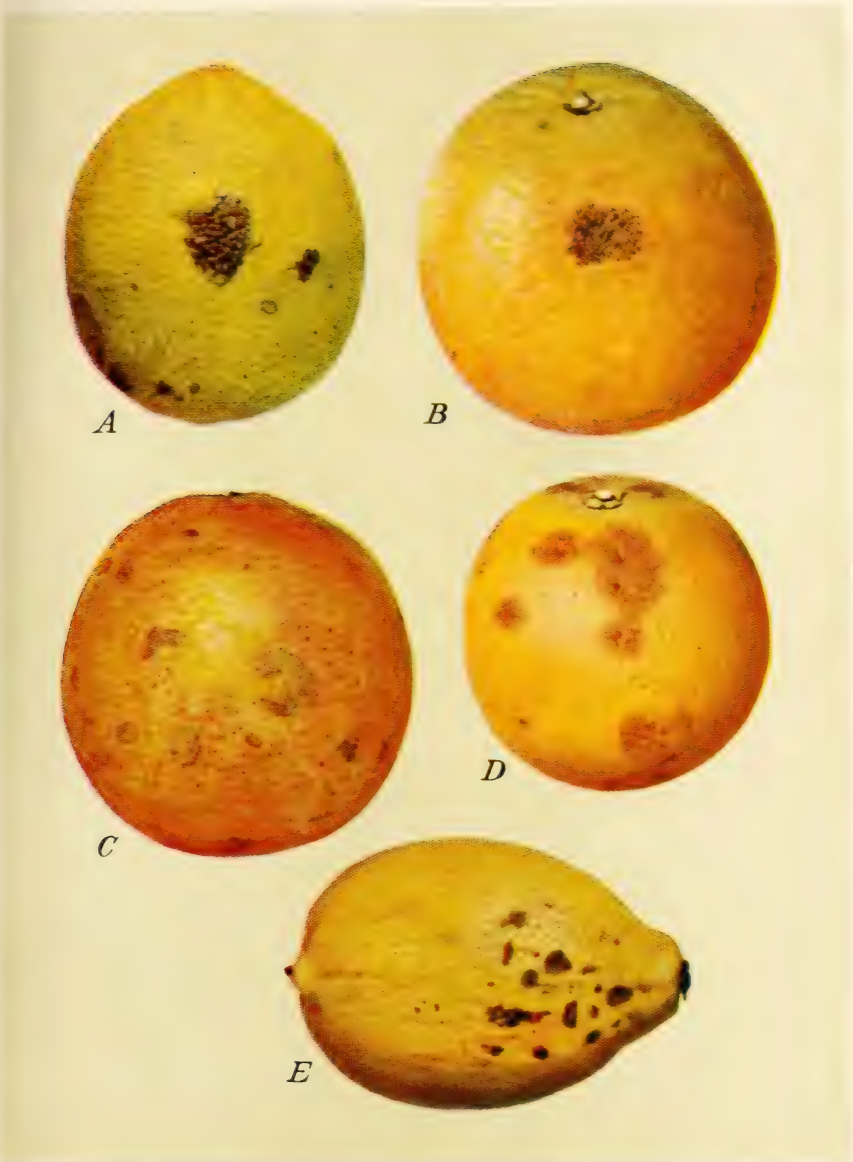
Membranous stain, or membranosis of lemons, is characterized by a browning or darkening of the membranes or carpellary walls between the segments (pl. 7, *C* and *D*). The central core tissues and the inner tissues of the rind also may be affected. The disease can be detected only when the lemons are cut and can be seen best when the segments are pulled apart for longitudinal view.

The disease is more prevalent in fruit picked in cool, damp weather. It is extremely responsive to storage temperature; lemons held at 40° F. become seriously affected, whereas, curiously enough, those held at either 32° or 60° seldom develop sufficient stain to be seriously damaged. For the prevention of this and related diseases a storage temperature of 55° to 58° has been found most satisfactory.

(See *24*, *42*, *43*, *80*.)

OIL SPOTTING (OLEOCELLOSIS)

Oil spotting is found on citrus fruit from all producing regions. It is worse and probably most commonly seen on lemons and limes, but it is also found on other citrus fruits, especially oranges harvested early in the fall before they have lost their green color (pl. 11, *B*). The commonest form of the injury occurs as irregularly shaped yellow, green, or brown spots in which the oil glands of the skin stand out prominently because of slight sinking of the tissues between them (pl. 11, *A*). The yellow spots develop on fully colored mature fruit, whereas the green spots develop on fruit that was green in color when picked. Brown spots are either a later or older stage of spots that were originally green or of spots that were more severely injured. Spots seen on fruit on the market are usually not more than one-half inch across. Some of those observed on fruit in groves and packing houses are so large as to involve the greater part of the fruit surface. In either the green or the brown stage they become more evident after the fruit has been subjected to the degreening process.



A and *B*, Oil spotting: *A*, On lemon; *B*, on orange. *C* and *D*, Bordeaux-oil-spray injury on orange. *E*, Sulfur-spray injury on lemon.

Field observations and experimental work indicate that oil spotting is a form of bruising injury. It is particularly likely to occur on green citrus fruit if it is handled while wet. The immediate cause of the injury is oil that is liberated from the oil glands by mechanical injury. Pressure incident to the picking and handling of green-colored fruit is particularly likely to cause the green spots, and bruises incident to packing degreened fruit cause yellow or brown spots, the severity of the injury depending upon the quantity of oil released. Field freezing may also liberate oil and cause spotting. Fruits with raised, prominent oil vesicles are more likely to suffer from oil spotting than those with less prominent ones.

(See *39*, *43*, *75*, *119*.)

PETECA

Peteca resembles pitting, but the depressions are more gently rounded at the edges (pl. 1, *C*). The collapse begins with the albedo, and the outer layer of the rind sinks without at first losing its normal color. The oil glands soon begin to darken, and in extreme cases the whole surface layer may collapse and become discolored.

Peteca may develop in storage, but its occurrence seems to be largely determined by previous orchard and climatic conditions. It is most common on fruit picked in cold, wet seasons.

(See *24*, *43*.)

PITTING

Lemons sometimes become pitted if held for prolonged periods in low-temperature storage (32° to 40° F.). The depressed areas of the rind may range from one-sixteenth to one-half inch in diameter. They sometimes retain their normal color but more often become light brown or dark brown approaching black.

The disease is rare on lemons held at a temperature of 50° F. or higher, but it is likely to become serious on those held at 40° or lower for more than a few weeks. A comparison of these statements with those made in this publication relative to the control of other lemon diseases brings out an important fact; namely, that the temperature commonly used for the storage of lemons, 55° to 58°, is really a compromise. Below that range there is danger of serious loss from physiological diseases—membranous stain, pitting, and red blotch—whereas at higher temperatures heavy loss from fungus diseases is almost sure to result. Within the range chosen there is a balance between the two groups of diseases that permits profitable commercial operations.

(See also *80* and references under Grapefruit, Pitting, p. 5.)

RED BLOTCH (ADUSTIOSIS)

Red blotch, or adustiosis, is a superficial scaldlike browning of the surface layers of the lemon rind (pl. 1, *B*). At first it may be a light cinnamon brown, but in later stages it may darken into a chestnut brown.

The disease is limited largely to fruit picked in cold, wet seasons and appears to be aggravated by forced curing. It seldom develops in transit or on the market, but it is sometimes found on fruit that has been held at 36° or 40° F.

(See *24*, *42*, *43*.)

SCAB

(See Grapefruit, Scab, p. 7, and pl. 1, *D*.)

SEPTORIA SPOT AND STAIN

(See Oranges, Septoria Spot and Stain, p. 31, and pl. 15, *B*.)

STEM-END ROT

(See Grapefruit, Stem-end Rot, p. 7, and pls. 5, *A*, and 6, *A*.)

SOUR ROT

(*Oospora citri-aurantii* (Ferr.) Sacc. and Syd.)

Sour rot develops occasionally on citrus fruits if they are overmature or have been held for a long time in storage. Lemons and limes are more commonly affected than other species of citrus fruits.

The decaying areas are at first water-soaked, slightly raised above the healthy surface, and dark buff yellow. Later a thin water-soaked layer of compact cream-colored hyphae develops on the surface. The decay involves the tissues of the rind and segment walls more rapidly than it does the juicy vesicles. It is extremely soft and mushy, so that the decayed tissue sloughs off with slight pressure and smears over the rest of the fruit in the package. In late stages the decay is characterized by a sour, putrid odor. It is frequently accompanied by other decays and by the larvae of insects.

The causal fungus enters through wounds or areas in the skin killed by other diseases. On limes it commonly follows spotting or stylar-end break-down. After the decay has started in one fruit it may spread to neighboring sound ones. When *Oospora* is associated with other citrus-rotting fungi, the decay produced develops much more rapidly than if produced by any of the fungi alone.

(See *42*, *43*, *101*, *105*.)

SPRAY INJURY

(See Oranges, Spray Injury, p. 32, and pls. 6, *D*, and 11, *C–E*.)

THRIPS INJURY

(See Oranges, Thrips Injury, p. 33, and pl. 18, *B*.)

TRICHODERMA ROT

(See Oranges, Trichoderma Rot, p. 34.)

WATERY BREAK-DOWN

(See Grapefruit, Watery Break-down, p. 10.)

LIMES

ANTHRACNOSE

(*Gloeosporium limetticolum* Clausen)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Key (Mexican) limes received at the market from any of the commercial producing regions are frequently affected with corky, scablike

excrescences. Other varieties of limes are reported to be immune to the disease. The common anthracnose of citrus, including limes, is caused by a less actively pathogenic organism, which does not produce the corky fruit spots characteristic of lime anthracnose.

Lime anthracnose occurs as a blossom blight, a leaf spot, and a die-back of tender twigs as well as corky spots on the young fruit. Leaves and twigs as they near maturity and fruits after they are three-fourths inch in diameter become immune to attack. If the fruit is severely infected when very young it may fall from the tree. At first the spots on the fruit are a water-soaked brown and slightly sunken, but later they become flesh color with the formation of raised corky scabs. Frequently the fruit becomes distorted and cracks through the spot, exposing the juice sacs below. The affected areas do not enlarge after the fruit is picked, but secondary organisms may enter through the cracks and cause decay. Occasionally the scabby excrescences may fall away from spots leaving a rough slightly sunken scar. The disease on the fruit may have somewhat the appearance of citrus scab, but there need be no confusion because the latter has not been found on the Key variety of limes.

CAUSAL FACTORS

The disease is caused by the fungus *Gloeosporium limetticolum*, which is peculiar to the Key lime, not having been found on other species of *Citrus*. It lives from year to year on affected twigs and leaves.

CONTROL MEASURES

Although the disease may be controlled with lime sulfur or bordeaux mixture, spraying is rarely done on the Florida Keys because of the difficulty of getting spray machines into the groves and because so many applications are necessary if all of the flushes of new leaves, twigs, and fruits are protected. The sparing use of nitrogenous fertilizers or their application at a time that will not produce flushes of tender growth during the wet seasons when infection is most severe is an important control measure.

(See *32*, *43*, *53*, *82*.)

BLUE MOLD AND GREEN MOLD ROTS

(See Oranges, Blue Mold and Green Mold Rots, p. 19, and pl. 6, *B* and *C*.)

FREEZING INJURY

(See Oranges, Freezing Injury, p. 27, and pl. 16, *A*–*C*.)

OIL SPOTTING (OLEOCELLOSIS)

(See Lemons, Oil Spotting (Oleocellosis), p. 14, and pl. 11, *A* and *B*.)

RIND BREAK-DOWN

Both Key (Mexican) and Tahiti (Persian) limes are subject to a conspicuous spotting or collapse of the rind during transit and storage. Affected areas occur on any part of the fruit but are more common on the sides than at the stem and stylar ends. Because large areas

of the surface are usually involved the name "scald" has often been used for this trouble. These areas are sunken, having distinct and abrupt margins, and vary in color from tan through rusty pink to deep brown (pl. 1, *E*). Oil vesicles in the affected area are not as prominent as with oil spotting. Only the outer part of the rind is affected, so that unless the fruit is severely spotted the flavor of the juice is not affected. The spots afford entrance to decay-producing organisms, such as those causing blue mold rot, black mold rot, and sour rot.

Rind break-down may result from several causes. Limes stored at a temperature of 40° F. or lower are more subject to the spotting than those held at 45° or above, although when held at the higher temperature for periods of 8 weeks or longer they usually develop some of the trouble. At low temperature the injury is more severe on immature than on riper fruit. Limes stored in a dry atmosphere are more subject to rind break-down than those held under moist conditions. Some of the spots undoubtedly result from rough handling during packing and shipping.

Control measures consist of careful handling, prompt shipment, and storage at temperatures between 45° and 48° F. and relative humidities above 85 percent.

(See *122*.)

STEM-END ROT

(See Grapefruit, Stem-end Rot, p. 7, and pls. 5, *A*, and 6, *A*.)

STYLAR-END BREAK-DOWN

Tahiti (Persian) limes as they approach maturity either on the tree or after picking are susceptible to a collapse of the rind at the stylar or blossom end of the fruit. Frequently in shipments containing fruit of the "turning" stage of maturity, from 5 to 10 percent are affected. Limes that are apparently sound when packed may become badly affected during a 4-day transit period. During the summers of 1937, 1938, and 1939 stylar-end break-down was the most important transit disease of this fruit from Florida. The disease has been noted occasionally on Key (Mexican) limes and on lemons.

Usually the disease appears first at the base of the nipple or tip as a grayish tan, water-soaked spot. The affected area enlarges rapidly involving the stylar end up to one-third or one-half of the fruit. Occasionally the disease appears at the stem end as well as at the stylar end. The affected area remains firm but becomes darker with age and usually sinks below the healthy surface. There is often a partial collapse of the flesh within the stylar end of the fruit and a water soaking of the core tissue. The affected rind is quickly invaded by organisms such as *Oospora*, *Aspergillus*, and *Colletotrichum*.

Since in early stages no organism has been found associated with the disease, it is considered physiological in nature. The only control measure that can be recommended is picking the fruit before it becomes too mature.

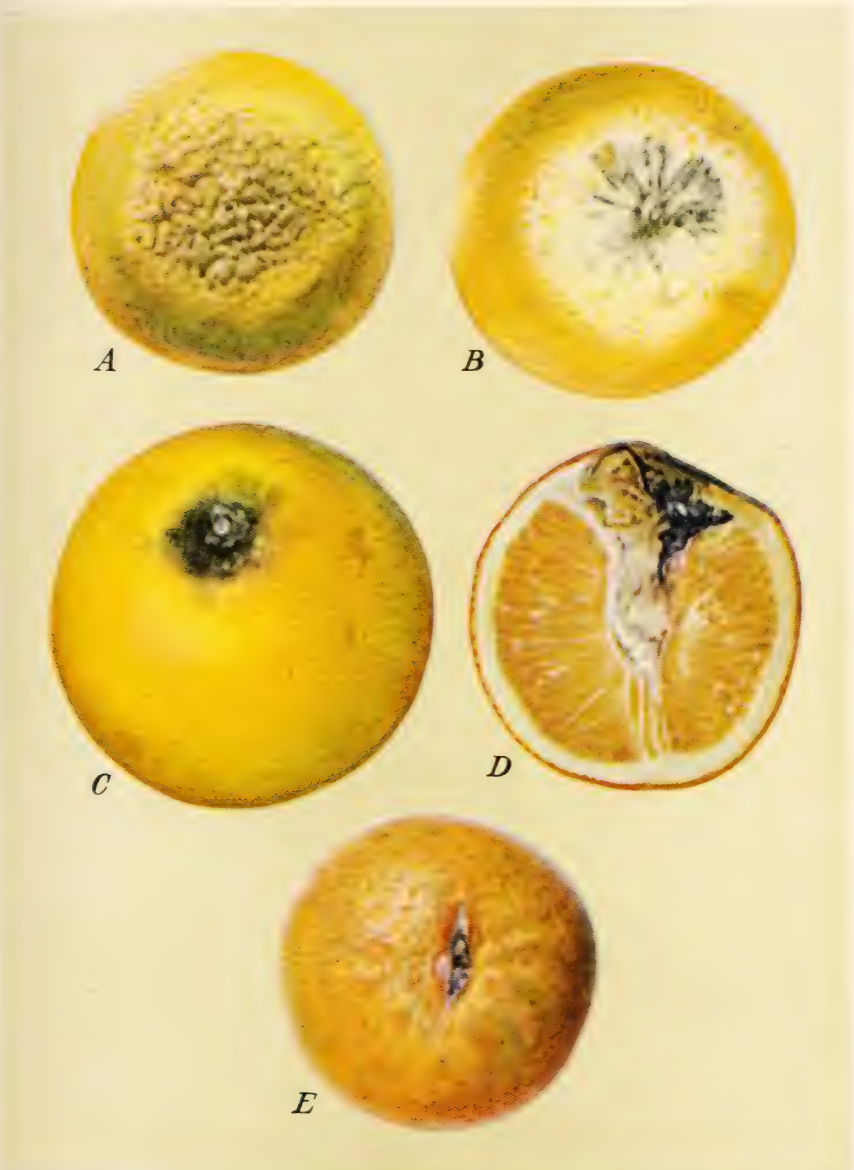
(See *43*, *96*.)

Oranges

AGING

The term "aging" is used in referring to the condition sometimes found after harvest on citrus fruit, chiefly oranges and grapefruit, in

A and *B*, Aging on orange: *A*, Early stage; *B*, late stage. *C*, Heat injury on orange from hot dye solution. *D*, Coloring-room injury on orange. *E*, Brown stain on California Valencia orange.



A–D, Black rot on orange: *A*, At stem end, external view; *B*, just below button, cross section; *C*, after 3 months' storage at 32° F.; and *D*, at navel. *E*, Stylar-end (blossom-end) splitting, without internal infection, on orange.

which the rind around the stem button or elsewhere on the upper part of the fruit becomes wilted and shriveled, with or without collapse of outer rind tissues (pl. 12, *A*). This condition is apparently caused by loss of water from the fruit and is frequently accompanied by a browning of the affected areas and collapse of the oil glands (pl. 12, *B*). Browning, however, may also be caused by improper conditions in the coloring room or by the use of heated solutions in washing the fruit or in the "color-added" process (pl. 12, *C*). In examining oranges or grapefruit from storage it is sometimes difficult to tell with certainty whether the small brown sunken spots found are pits or "aged" spots. For the present it seems desirable to call such spots aging if they occur near the stem and are dark brown, and pitting if they occur on the lower part of the fruit and are dark to light brown or not discolored at all.

Fruits showing extreme symptoms of aging, accompanied by browning, usually have an off or aged flavor.

Another form of aging found late in the season of any variety of tangerines and oranges is the development of minute cracks, in roughly concentric pattern, in the rind around the stem. These cracks may develop on normal-colored rind, but later the affected area turns a pale brown or tan, and still later a few large pits may develop on the affected area. This condition may be found even before the fruit is harvested.

ANTHRACNOSE

(See Grapefruit, Anthracnose, p. 3, and pl. 1, *A*.)

BLACK ROT (ALTERNARIA ROT)

(*Alternaria citri* Ell. and Pierce)

Black rot is particularly serious in California navel oranges and occurs as a brownish or black slow decay at the stem end or the stylar end of the fruit (pl. 13, *A–D*). Infection takes place through the navel when the fruit is young and is apparently responsible for part of the June drop. Affected fruits that do not drop but remain on the tree usually color ahead of the main crop. They may show the disease only when cut, or they may, in transit or storage, develop a rot that involves the whole blossom end and is visible from the outside. When only the interior of the navel is affected the tissues are black; when the decay reaches the outside the rind shows merely a dark-brown color. The disease is sometimes found accidentally in a lot of oranges that is being cut for transit freezing injury, when otherwise its presence would not have been suspected.

Black rot sometimes causes rather heavy loss in the grove but is not common on the market. It develops rather slowly at temperatures below 50° F. but is sometimes found even at 32° on both grapefruit and oranges held for 8 to 10 weeks (pl. 13, *C*).

(See *33*, *43*.)

BLUE MOLD AND GREEN MOLD ROTS

(*Penicillium italicum* Wehmer and *P. digitatum* Sacc.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Blue mold and green mold rots, sometimes known as penicillium rots, are probably the commonest of all the rots that affect citrus fruits.

They occur in all parts of the world where these fruits are grown and may attack them in the packing house, in transit, in storage, and on the market. They are not often found on fruit hanging on the tree, except after mechanical injuries. Green mold rot is much more prevalent than blue mold rot.

Both rots first become apparent to casual examination as soft, watery, decolorized spots in the rind, about one-fourth to one-half inch in diameter. These constitute the so-called pinhole rot; under favorable conditions they enlarge to spots 1½ to 2 inches in diameter within 24 to 36 hours and are then sometimes known as blister rot. Soon after this stage is reached the mold begins to appear on the surface of the decaying areas.

In green mold rot the older portion of the fungus growth has an olive-green color but is usually surrounded by a broad zone of white mycelium, ahead of which is an indefinite band of softened rind (pl. 6, *B*). In blue mold rot the fungus growth is blue, almost up to its edge, and there is a definite band of water-soaked rind just ahead of the mycelium (pl. 6, *C*). The surface of the green mold growth is wrinkled, and that of the blue mold growth is powdery or velvety. Blue mold sporulates on the surface and also in the flesh, sometimes clear to the center of the fruit. Green mold sporulates only on the surface. The wrappers adhere closely to fruits rotted by green mold but not to those rotted by blue mold.

CAUSAL FACTORS

Most of the damage from these rots takes place after the fruit leaves the producing region, although it frequently seems to be correlated with weather conditions prevailing at time of harvesting and packing. Fruit picked before or just after warm wet weather often suffers severely later from the rots; the same is true of fruit picked during fairly dry weather but held in the packing house and packed out while still damp during rainy or foggy, warm weather.

The chief factor, however, that favors the development of these rots is mechanical injury of some kind, since both causal fungi enter readily at such injuries. Skin breaks may result from careless harvesting and packing methods, from too high a bulge on the packed boxes, from rough handling in transit, or from shifting and breakage caused by improper stowing of the load. However caused, they are always a source of danger to the fruit. Blue mold is also able to grow through the uninjured skin of citrus fruit and for that reason is often called the blue contact mold.

The amount of rot that develops after fruit is removed from a car or a storage room depends largely on what stage is reached before that time. If, when the rot is sorted out, most of it is found to be in the early or pinhole stage, there probably are other spots in still earlier stages that will soon make another culling necessary; but if most of it is so far advanced as to show the mold and the green or blue color, there is probably little danger that more rot will develop unless the rest of the fruit was carelessly handled and became contaminated with spores during the sorting process.

The third important factor influencing the development of these rots is temperature. At 75° F. both molds make their best growth. At

59° there is some checking that amounts to about 5 or 6 days extension of the time during which the fruit can be marketed at a profit. At 50° the first really satisfactory checking is obtained with a further extension of the safety period by 5 or 6 days. At temperatures between 40° and 45° the growth of both molds is so slow as to be practically negligible during the ordinary commercial handling period for citrus fruit. Blue mold can develop very slowly at low temperatures that more completely inhibit green mold.

CONTROL MEASURES

The control of blue mold and green mold rots depends first of all on careful handling throughout the harvesting, packing, and marketing processes, in order to keep the fruit as free as possible from skin breaks and bruises. For the control of green mold it is highly desirable to treat the fruit with a borax solution as described under Grapefruit, Stem-end Rot (p. 7). The blue contact mold not only is not controlled by the borax treatment but often is actually increased by it. The reason for this is thought to be that when green mold is practically eliminated by the use of borax, blue mold has a free field and progresses more rapidly than if the green mold were present (*43*).

Holding the fruit at temperatures between 40° and 45° F. gives good control of green mold and blue mold rots. The storage temperature of 32° to 34° recommended for oranges and sometimes desirable for grapefruit will usually hold the rots in check during the period for which these fruits can safely be stored. Grapefruit stored at 45° to 55° may suffer some damage from these rots, but it is in less danger of being damaged by pitting than if stored at 36° to 40°. Blue mold rot is markedly checked by maintaining the coloring-room temperatures between 80° and 85°. (See p. 24.)

Fruit that is to be shipped to market should be precooled promptly after being packed or placed in the refrigerator car. Refrigeration in transit is necessary except during the winter months in order to prevent the development of decay.

(See *9*, *42*, *43*, *44*, *54*, *74*, *92*, *96*, *117*, *139*, *141*, *143*.)

BROWN STAIN (SCALD)

The terms "brown stain" and "scald" have been used to refer to what is apparently the same disease, namely, a superficial and fairly uniform browning over relatively large areas of the rind (pl. 12, *E*). The disease stands out in marked contrast to all forms of pitting because of the extent of the areas affected and the fact that they are never as much or as sharply depressed as in pitting. In mild and typical cases the rind is firm, but in severe cases it may become spongy and soft. The color of the affected rind is seldom as dark as that found in severe pitting. Brown stain is practically always worse on overmature, highly colored fruits.

Brown stain is a disease that affects oranges while under refrigeration. It is much more common on fruit held at 32° F. than on that held at higher temperatures, but it has been found to a greater or less degree on fruit held at temperatures as high as 40°, particularly if subjected to air-blast refrigeration.

(See *23*.)

CALIFORNIA RED SCALE

(*Aonidiella aurantii* (Mask.))

The California red scale is a serious pest of citrus fruit in many parts of the world, but it is found chiefly in regions having a semiarid climate like that of California, Australia, and South Africa. At the stage of development most likely to be found on fruit on the market it is bright red to black, rather than reddish brown as in the case of the Florida red scale. In gross appearance, except color, the two scales are very similar.

Fumigation is recommended for the control of this insect.

(See *81*, *94*, *100*, *131*, *132*.)

CHEWING-INSECT INJURY

When citrus fruits are young they are sometimes attacked by grasshoppers, katydids, and other chewing insects, which eat away the rind over areas of varying size on any part of the fruit. Some of these injuries are probably so severe that they cause the fruit to drop; others heal over, producing a roughly circular, or sometimes oblong, smooth scar which at the edges is sharply sunken below the level of the rest of the rind (see pl. 18, *D*). These sunken scars are rarely discolored.

Grapefruit and oranges may be affected, as well as lemons.

CITRUS RUST MITE RUSSETING

(*Phyllocoptruta oleivorus* (Ashm.))

OCCURRENCE, SYMPTOMS, AND EFFECTS

The citrus rust mite occurs in the Gulf States and the West Indies and to a slight extent in California. It is not a serious pest of citrus fruit anywhere in the last-named State. Although it may attack all commercial varieties of citrus, most of the damage is done on grapefruit and oranges. The mite is a minute member of the spider family, which sucks the juice from both leaves and fruit and thereby injures them. Several types or degrees of the injury are recognized.

(1) Injury produced by very early infestation. This is characterized by slight, scattered, more or less crisscross or star-shaped brown etchings or russeting of the rind near the stylar end of the fruit. It is sometimes mistaken for copper-spray russeting or for the effect of rubbing while the fruit is on the tree. This type of blemish is found mostly on oranges.

(2) Injury caused by somewhat later but severe infestation and known as "sharkskin" (pl. 5, *B*). Practically the entire surface of the rind of fruits affected by this blemish becomes slightly roughened, abnormally thick, and of a pale grayish or silvery appearance. Young fruits are often stunted in growth; fruits of normal size are commonly light in weight and contain less than the usual amount of juice. Sharkskin is much lighter in color than melanose. This type of citrus rust mite russeting, which is found chiefly on grapefruit and occasionally on lemons and limes, is not often seen on the market. It does not spread in transit, but the damage done by it to the market value of the fruit is considerable, since much of what would otherwise be classed bright fruit must be placed in the russet class solely

because it shows sharkskin. Sharkskin is rare on oranges, but the degree and period of infestation that produce it on grapefruit cause the so-called black russet condition on oranges.

(3) Injury caused by the common summer infestation. In this type the russeting usually occurs in solid though poorly defined areas or patches that may involve most of the surface of the fruit. It is also found in streaks about one-eighth to one-fourth inch wide, occurring either alone or as extensions toward the blossom end from a larger russet area on the top or side of the fruit. These streaks, known as citrus rust mite tearstaining, were at one time thought to be caused by the anthracnose fungus (*Colletotrichum*), but so far as Florida is concerned are now known to be merely one form of citrus rust mite injury (for other forms, see Grapefruit, Tearstaining, p. 10, and Grapefruit, Melanose, p. 5). A similar-appearing injury of lemons in California is known as tearstaining, but it is caused by the anthracnose fungus (p. 3).

(4) Injury by late fall or winter infestation. This is usually so slight that it produces merely the so-called golden or bronze effect that prevents the fruit from being classed as bright.

Russeted fruit is less attractive in appearance than bright fruit and brings a lower price. The injury to the skin does not seem to render the fruit more liable to decay, but it does cause it to lose water and shrivel rather rapidly under ordinary merchandising conditions.

The citrus rust mite is light yellow, wedge-shaped, and, when full-grown, about one two-hundredths of an inch long. It is not likely to be found on fruit that has gone through the washing and polishing processes in the packing house, but the evidence of its prior presence, of course, remains.

CONTROL MEASURES

The best results in controlling the citrus rust mite have been obtained by applying sulfur or some of its compounds either as a dust or in the form of a spray, the applications being made at any time when the mites are found to be unduly numerous.

(See *94*, *100*, *131*, *132*, *135*.)

COLORING-ROOM INJURY

Citrus fruit subjected to ethylene treatment sometimes suffers an injury that is characterized by a brown spotting of the rind (pl. 12, *D*). This spotting, often erroneously called "gas burn," is not caused by ethylene but by too low humidity in the coloring room; it is found on fruit subjected to dry air in which there is no trace of coloring gas, as well as on gassed fruit. The brown spotting develops on any part of the fruit during the gassing period and can be detected readily when the fruit is graded in the packing house. In general appearance it closely resembles brown stain (p. 21) but is perhaps a little darker in color. This is especially true on grapefruit. The discolored areas rarely enlarge after the fruit is packed and seldom afford an avenue for the entrance of decay organisms.

This blemish is likely to be encountered early in the season when the fruit is tender and relatively immature. It has usually been found where attempts were being made to "force" coloring by the

use of too much heat and inadequate circulation. When the offending condition is corrected "gas burn" does not occur.

The browning caused by too low humidity in the coloring room can be distinguished from that which accompanies aging of the fruit in storage by the roughened, papery appearance of the surface of the rind and by the fact that affected areas are not sunken. Areas showing the blemish known as brown stain (p. 21) do not develop until after shipment or storage and are neither sunken nor roughened.

Brown spotting in the coloring room can be reduced by maintaining the relative humidity at 90 to 92 percent or above during the ethylene treatment.

Another kind of coloring-room injury is the more rapid development of stem-end rot in gassed fruit. However, this is due not so much to the effect of the ethylene as to the more rapid aging brought about by improper operation of the coloring rooms. It can be prevented to some extent by maintaining a moderate circulation of air in the coloring room throughout the coloring period and not allowing the temperature to go above 85° F. Best results from the ethylene treatment are obtained when the temperature is maintained between 80° and 85°, which markedly checks blue mold decay (p. 21).

CREASING

Creasing is a condition found in mature and overmature oranges and is characterized by narrow sunken furrows or grooves in the rind, usually less than ¼ inch wide and from ½ to 2 inches long (pl. 14, *A*). These may extend both longitudinally and crosswise and in severe cases may run together to produce large areas of bumpy rind. In small creases the color of the sunken skin is normal, but in larger ones it may be yellowish green to gray. On fruits that have been subjected to hot solutions, such as those often used in the "color added" treatment, creases become more apparent, the sunken rind often becoming water-soaked or cracked. Sinking of the rind in the creases is due to weakness in the underlying spongy portion. If a thin paring is made so that the tissue bearing the oil cells and yellow color is removed from the crease, it can be seen that the albedo is thin or cracked and pulled apart (pl. 14, *B*).

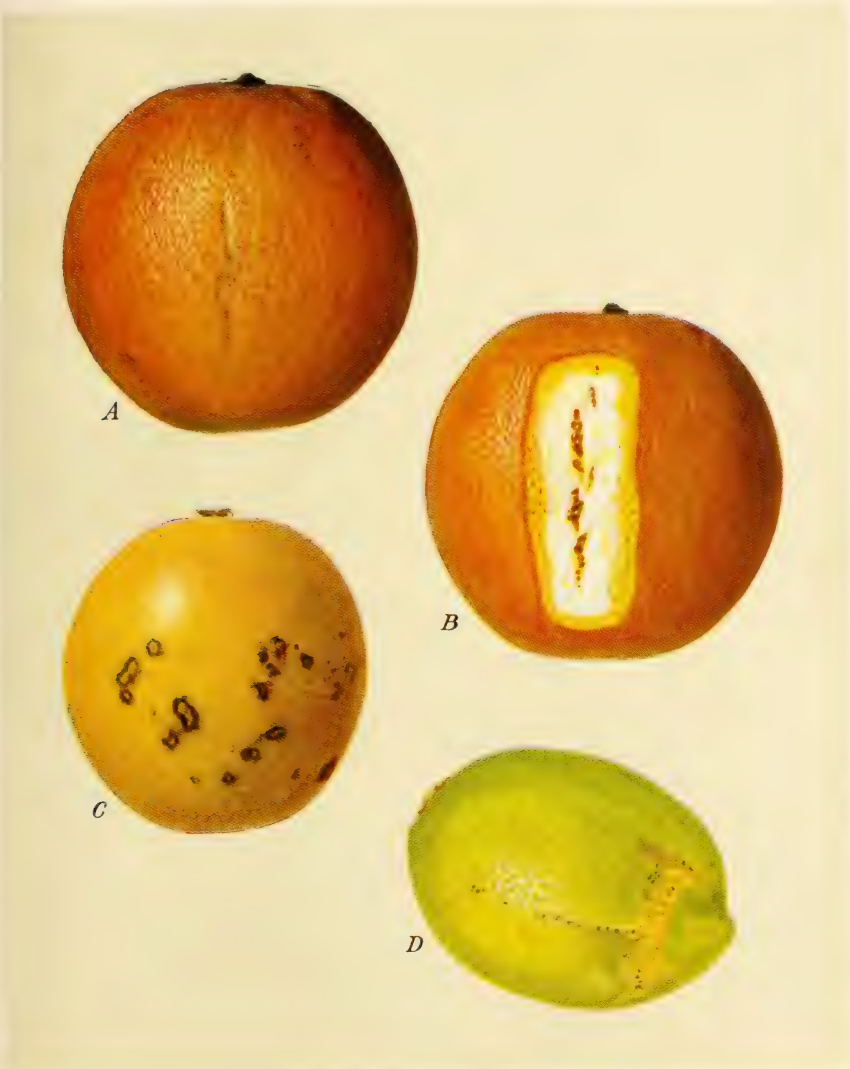
In California oranges mild creasing is not considered a serious defect because the rind is pliable and few of the fruits crack open from pressure during packing and shipping. Florida fruit, however, has a thinner and more brittle rind so that creased areas split easily in tight packs and open the way for blue and green mold rots. The cause of creasing is not known. Except in fruit subjected to hot solutions or too tightly packed, very little if any increase in amount or severity of creasing has been observed in transit.

(See *43*, *96*.)

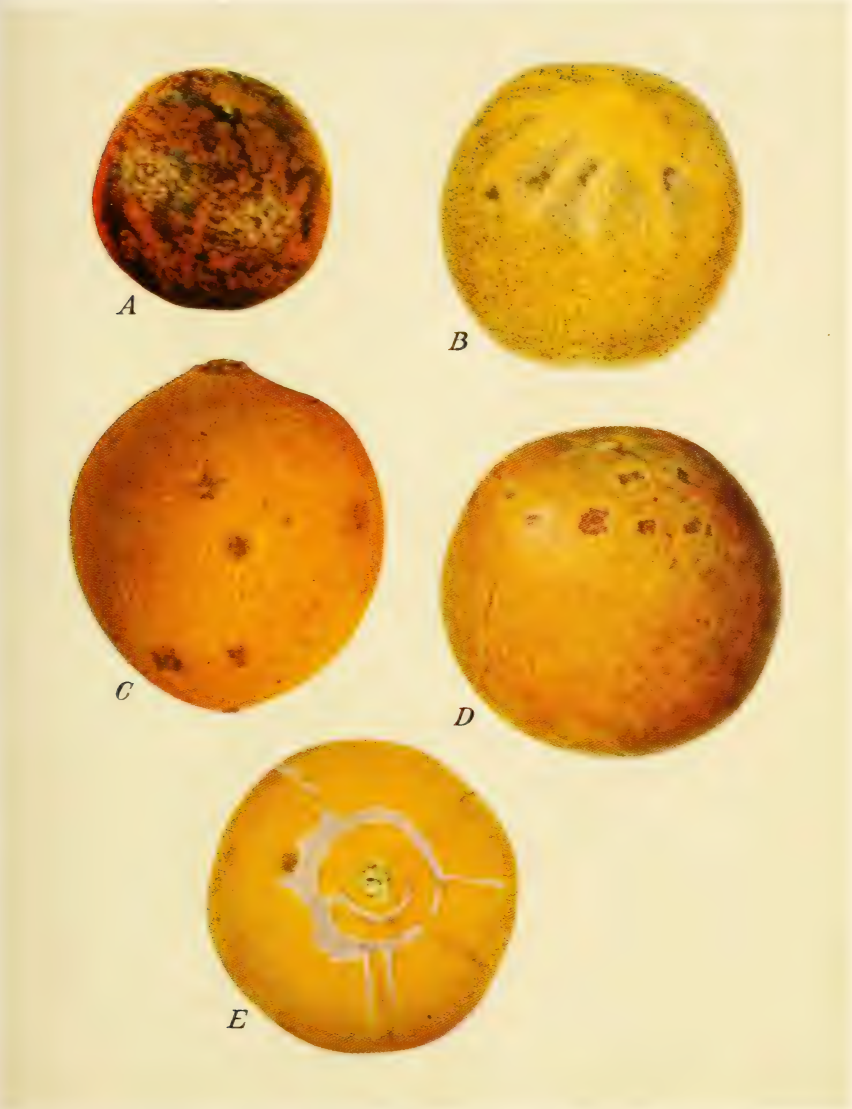
EXANTHEMA (AMMONIATION)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Exanthema is a nonparasitic disease of the fruit, leaves, and twigs of all commercial *Citrus* species. It occurs in practically all the citrus-growing regions of the world but in the United States is most common and most serious on oranges in Florida.



A and *B*, Creasing on orange: *A*, On rind; *B*, tangential section of rind showing crack in albedo. *C*, Fumigation injury on orange. *D*, Fumigation injury on lemon.



A, Exanthema on orange; *B*, septoria spot and stain on orange; *C*, pitting developed on navel orange in storage; *D*, pitting developed on Florida orange on the tree; *E*, thrips injury on California orange.

The distinguishing characteristics of the disease are gum pockets and bark excrescences on the twigs and smaller branches, stained terminal branches, dying back of the branches, and dark-brown to almost black, glossy spots on the rind of the fruit (pl. 15, *A*). The latter may be of various sizes and shapes, but usually their first stage on oranges consists of brown gum pockets in the oil glands of the rind. Gum pockets may sometimes be found in the albedo of thick-skinned oranges when no symptoms appear on the surface of the fruit. These are probably an incipient stage of the disease. In grapefruit the gum pockets are found most frequently in the albedo. Gum may also form in the angles of the segments of the fruit along the central axis or core.

On oranges the affected spots eventually become elevated so that they appear either as pimples or as large irregular scarred areas. The pimples vary from about one thirty-second to one-eighth of an inch in diameter and are sometimes found so close together that they almost touch, over a large part of the surface of the fruit. There are two types of scars, one rough and dark reddish brown like the pimples, and the other fairly smooth and dull grayish brown to almost black. The rough scars are very often deeply cracked, whereas the smoother ones rarely show more than a superficial checking (pl. 3, *B*).

Both kinds of scars occur as spots about one-fourth to one-half inch in diameter or as irregular bands or streaks, which may be so large as almost to encircle the fruit. In both of these the rind is rather hard and stiff and as a result often becomes cracked as the orange grows or because of the greater rapidity with which the affected portions dry out during the marketing process. Cracks probably arise also from even ordinarily careful handling of fruit which has this stiff, brittle covering. Oranges affected by the disease do not carry well in transit, the reason probably being that *Penicillium* and occasionally the stem-end rot fungus find easy entrance at the cracks in the affected rind.

The pimple stage of exanthema on the fruit is sometimes mistaken for melanose. The two can be distinguished by the fact that the pimples of melanose are dark brown surrounded by gray and when examined under a hand lens are seen to be cracked away from the healthy rind around them (pl. 3, *A*); those of exanthema are dark reddish brown and, if they are cracked at all, the cracks appear across the top (pl. 3, *B*). The pimples of exanthema originate in tissues beneath the epidermis and thus seem to come up through the epidermis. Melanose is on the surface of the rind.

On grapefruit, exanthema occurs most often as either craterlike or concave depressions about one-sixteenth to one-fourth inch in diameter, or, more rarely, as flat areas half an inch to an inch or more in diameter and very slightly depressed below the surrounding healthy rind. The surface of the spots, large or small, is usually gray to almost white. In the white spongy part of the rind, and easily seen on cutting, are reddish-brown gum pockets having roughly the diameter of the gray area on the surface. Similar brown spots can sometimes be found in the rind of affected oranges, but they are always near the surface, whereas those in grapefruit may extend clear to the membrane overlying the juice sacs.

Exanthema may occur anywhere on the surface of grapefruit but is most common at or near the ends. Even in the large flat spots de-

scribed above it does not show the cracking so often seen on oranges. So far as known it has no harmful effect on the carrying quality of grapefruit.

CAUSAL FACTORS

The cause of exanthema is not known. The disease is found most commonly, however, on trees where there is poor drainage and where the soil is underlain by hardpan, is subject to irregular moisture conditions, or has been given excessive cultivation. It is also found on trees oversupplied with organic nitrogen. It seems to be a nutritional disorder, possibly due to copper deficiency, under certain growth conditions.

CONTROL MEASURES

The most important thing to do in attempting to control exanthema is to ascertain, if possible, the soil condition or cultural practice that induced its development and to correct this by providing the trees with the proper conditions for making normal growth. This may mean any of the following procedures: (1) Blasting hardpan or cutting ditches through it, (2) withholding nitrogenous fertilizers, or (3) stopping cultivation during most of the year. If it is evident that exanthema has not been brought on by overfeeding, small quantities of stable manure may be helpful in controlling the disease.

In Florida good results in controlling exanthema have been obtained by spreading copper sulfate on the soil under affected trees at the rate of one-fourth pound to 4 pounds to each tree, the quantity used depending on the size of the tree; and by spraying with bordeaux mixture. Copper sprays applied for scab or melanose also control exanthema, although the evidence suggests that improvement results from correcting a copper deficiency rather than from killing an organism by the spray.

(See *43*, *51*, *96*.)

FLORIDA RED SCALE

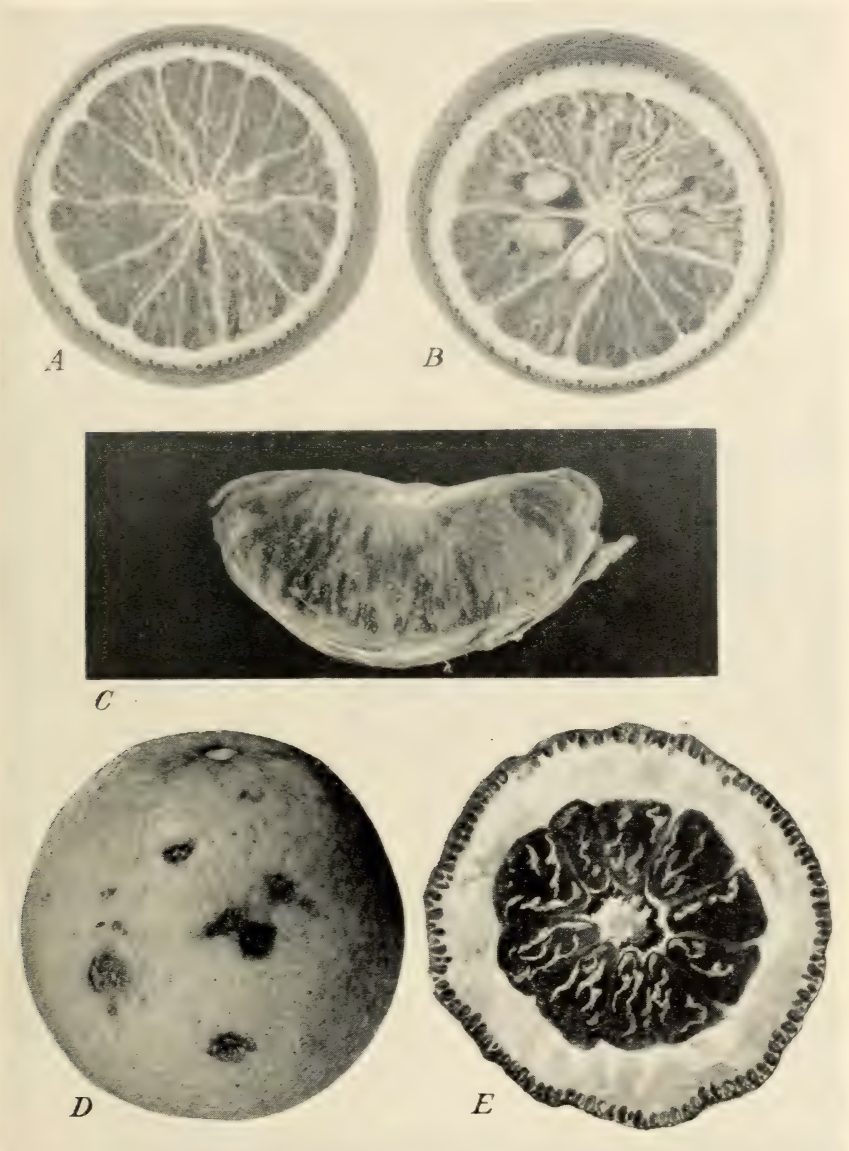
(*Chrysomphalus aonidum* (L.))

The Florida red scale infests citrus and mangoes (tree and fruit) and many other plants in the Gulf States and other subtropical regions. The female scale is dark reddish brown with a conspicuous light-brown center, almost circular in outline, and about one-twelfth of an inch in diameter when full-grown (see pl. 18, *E*.) Most of the injury that it causes is through the extraction of sap from the leaves and fruit. It has been observed that areas of the rind that are heavily infested with Florida red scale frequently show rind break-down and drying out.

Fruit infestation usually occurs during the summer or early fall. If more than slight, it is likely to result in a roughening of the rind, with shallow depressions where the scales were located. Infested fruit loses its green color more slowly than scale-free fruit, although the infestation may have been killed either by natural means or by the use of sprays prior to harvesting. It is exceedingly difficult to completely degreen with ethylene early ripening crops attacked by Florida red scale. On the tree the fruit will eventually attain full color, and the rind may become smooth after the scale has been killed, but this takes a long time.

Spraying with oil is recommended for the control of this scale.

(See *81*, *94*, *100*, *131*, *132*, *146*.)



A, Localized freezing injury of orange, on the tree, showing slight buckling of segment walls and drying out of pulp. *B*, More severe and general freezing injury of orange, with marked buckling of segment walls and drying out of pulp. Note thickened rind, which follows freezing injury. *C*, Hesperidin crystals on segment walls, resulting from freezing injury of orange. *D*, Hail injury occurring late in the season on orange. *E*, Puffiness of California Valencia orange.

FREEZING INJURY

Investigations by the Bureau of Plant Industry indicate that Washington Navel oranges freeze at 26° to 28° F., Thomson Navel at a little higher temperature, Valencia at 26.5° to 28.9°, and lemons at 27.9° to 28.5°.

TRANSIT FREEZING

Freezing injury in transit is likely to occur in the fruit next to the side walls and along the floor of the car, rather than in fruit in the body of the load. It seldom shows in the form of drying out so characteristic of fruit frozen on the tree. Oranges are often bitter in flavor for a time after thawing, but this is not a consistent factor. If the freezing has been severe, the rind may show effects ranging in severity from almost typical brown stain to leaden-gray discolored areas of varying size, which greatly resemble watery break-down. The affected rind tissues may or may not be sunken, but when severely frozen they usually become soft and mushy and are underlain by mushy pulp tissue (see Grapefruit, Watery Break-down, p. 10).

Freezing damage is best seen by cutting off both ends of an orange, then cutting through the rind of the central portion remaining, and pulling the segments apart. If the fruit has been frozen the membrane between the segments will show a soaked condition and usually a number of white specks, which are hesperidin crystals (maringin in grapefruit) resulting from the freezing (pl. 16, *C*). However, the presence of hesperidin crystals in oranges is not necessarily an indication that the fruit has been frozen. They may also result from the application of heat to the fruit or from rapid drying out of the tissues. In tangerines the hesperidin crystals occur in the pulp as well as on the segment walls and are seen even more readily than in oranges when a cross-section cut is made. Freezing damage may be confined to a part of the fruit, in which case the signs suggested will be found in the affected part. The method of examination just described is particularly useful for California oranges. Florida oranges are not so easily examined in this way but are more likely to show the mushy condition in cross section.

Lemons and grapefruit show the damage in cross section much more plainly than oranges, although it is desirable at times to pull grapefruit sections apart as recommended for oranges. If lemons have been seriously damaged the pulp becomes mushy at once after thawing.

Grapefruit shows, in addition to the symptoms just described, a milky appearance of the pulp, which is in marked contrast to the very light amber color and the almost transparent condition of unfrozen pulp. The contrast is especially noticeable in fruits that have been frozen in small spots or only on one side. The milky appearance of the pulp is also found in grapefruit that has been in storage for 8 to 10 weeks and may be accompanied by a bitter taste. However, such fruit is not mushy and watery unless affected by watery break-down; in such a case, a positive diagnosis must depend on a consideration of the history of the fruit and the conditions under which the injury is found.

FRUIT FROZEN ON THE TREE

Citrus fruit frozen on the tree shows a number of symptoms described under transit freezing, if examined soon after the freezing

occurs. After a few days, however, additional symptoms appear. First and most characteristic among these is a buckling of the partition walls at the stem end of the fruit, with or without drying of the pulp (pl. 16, *A* and *B*). Small pits or pitted areas may also develop in the rind on any part of the fruit. In fruit on the market, picked several days after it had been frozen on the tree, the injury is manifest by woodiness of the pulp or by open spaces between the segments due to the collapse and drying out of some of the juice sacs. Cavities usually appear in the orange pulp before open spaces develop between the segment walls. Later, when considerable drying out of the pulp has occurred, small open spaces between the segment walls may be found. Sometimes only one or two segments will show drying-out effects and all or only a part of the segment may be affected. Where only one or two segments are affected, considerable time is required for them to dry an inch or more.

There are, of course, all degrees of dryness, from very slight to total. In the practical handling of citrus fruit three degrees are recognized: (1) Slightly open, when the cut surface shows a slight open space between the segment walls and the juice sacs but the surface of the pulp appears juicy. (2) Distinctly open, when the cut surface shows large open spaces but the pulp still appears juicy. (3) Dry, when the cut surface shows no large open spaces but the fruit seems to have dried out evenly all through and the color of the pulp shows it to be almost devoid of juice, or when the fruit has dried out with some of the segments more or less collapsed.

Drying in oranges usually progresses from the stem end, whereas in grapefruit it may proceed from either or both ends or it may begin around the outside of the pulp. Drying is not found at the center of the fruit except in extreme cases. If an orange that has been frozen is examined a few days after it thaws, it will usually show the hesperidin crystals already mentioned on the membrane or rag that separates the segments of the pulp. On the other hand, the crystals are sometimes visible when examination is made within a few hours after the freezing, whereas if it is not made until several weeks afterward they may not be so numerous or conspicuous, probably because the more severely frozen fruit falls soon after the freeze. In frozen tangerines the crystals may occur in the pulp as well as on the membrane between the segments. When examined on the market, tree-frozen fruit that has remained on the tree for several weeks after freezing has a rind that is thicker than normal, especially over the damaged part of the fruit.

As differentiated from granulation, dryness from freezing results through the emptying and subsequent collapse of juice sacs due to disappearance of the juice. In granulation the juice sacs do not collapse but become filled with gelatinous or solid matter.

(See *3*, *43*, *60*, *96*, *133*.)

FUMIGATION INJURY

Fumigation with hydrocyanic acid gas may cause injury to the fruit, leaves, young twigs, and trunks of citrus trees. The commonest form of the injury on the fruit occurs as pits of various sizes ranging from mere pin points to sharply sunken areas a quarter of an inch across or even somewhat larger. At first these have about

the color of the uninjured rind, but later they turn brown to almost black (pl. 14, *C* and *D*).

Fumigation injury is not often seen on the market, and when it does appear it is likely to be in the form of small, inconspicuous spots or pits that might be mistaken for small scars or for pits resulting from other causes.

(See *43*, *144*.)

GRANULATION

The dryness resulting from freezing on the tree has been discussed in the section on freezing injury (p. 27). Dryness may occur, however, when there has been no possibility of freezing, and it is then to be regarded either as a varietal peculiarity or the result of conditions under which the fruit was grown. This kind of dryness is known as granulation. It is found in all citrus-producing regions. Valencia oranges harvested late in the season or from young trees even in early or midseason are very likely to show it, particularly in the large sizes. In Florida, drought favors the development of granulation; in California, granulation sets in earlier in the season if there has been a lack of irrigation. Thomson Navel oranges and the larger sized Washington Navels grown in Florida are likely to show granulation no matter when they are harvested. In both these orange varieties the granulated condition appears sometimes throughout all of the pulp of affected fruits but more often only in the upper or stem-end portions. Even in fruits affected only at the stem end the granulation as seen in cross section affects all of the pulp and not merely small spots in two or three segments, as so often happens in freezing injury.

In tree-frozen fruit the juice sacs collapse, wither, and separate from each other and from the segment walls. The fruit is soft and light in weight. In granulated fruit the juice sacs do not separate from each other or from the segment walls; they remain turgid, the juice being displaced by solid matter that is yellow to grayish white in Florida fruit and grayish white in California fruit. Such fruit feels firm but is light in weight.

(See *18*, *19*, *20*, *43*.)

GRAY MOLD ROT

(See Lemons, Gray Mold Rot, p. 13, and pl. 10, *A*.)

HEAT INJURY

Citrus fruits are sometimes injured by heated washing solutions or by heated dye solutions used in the "color-added" process, especially when the fruit is immersed in the dye (pl. 12, *C*). The first symptom is the collapse of the oil vesicles accompanied by a strong orange odor if the fruit is stored in a closed room, probably due to distillation of oil. Eventually the injury shows as a brown area around the stem or as isolated brown patches or streaks elsewhere on the fruit. In both types the affected area is slightly sunken and the outer surface of the rind frequently has a collapsed or dried-out appearance and finally becomes hard and leathery. In early stages the fruit is softer at places where the injury occurs than at places where the rind seems normal.

Visible symptoms of heat injury become accentuated as time elapses after the fruit has been subjected to the heated solution. Consequently, on a given lot of fruit it is usually more noticeable on the market than at the shipping point.

If the browning here described is found at shipping point or on fruit just arrived on the market, it can be taken as evidence of heat injury. However, somewhat similar symptoms may be found on fruit from cold storage, in which case it could have resulted from too long an exposure to low temperatures, and probably should be called aging (p. 18), particularly if the fruit is known to have been in good condition when stored.

MELANOSE

(See Grapefruit, Melanose, p. 5, and pl. 2, *A* and *B*, and pl. 3, *A*.)

OIL SPOTTING (OLEOCELLOSIS)

(See Lemons, Oil Spotting (Oleocellosis), p. 14, and pl. 11, *A* and *B*.)

ORANGE TORTRIX INJURY

(*Argyrotaenia citrana* (Fernald))

In recent years the orange tortrix has become an important pest of oranges in California, particularly in the southern part of the State.

Orange tortrix injury consists of burrows just through the rind, made by the larva of the insect (see pl. 18, *C*). The injury blemishes the fruit, causes some of it to drop prematurely, and offers a place for easy entrance of decay organisms, especially under conditions that favor the development of water spot (see p. 34).

(See *93*, *118*.)

PITTING

(See Grapefruit, Pitting, p. 5, and pl. 15, *C* and *D*.)

PUFFINESS

Puffiness in citrus fruits is a condition in which the rind becomes thickened and somewhat soft and may become separated from the segments beneath so that it stands away from them and is loose. Affected fruits lose their natural shape in tight packs, and the loose rind sometimes cracks, thus affording easy entrance for the organisms causing blue mold and green mold rots.

Puffiness is found in mature and overmature fruit. In California oranges it is often associated with creasing, though fruit may be puffy without being creased (pl. 16, *E*). Puffiness is exceedingly rare in Florida oranges. Tangerines and satsumas, however, sometimes become puffy while still on the tree and often before they are ripe.

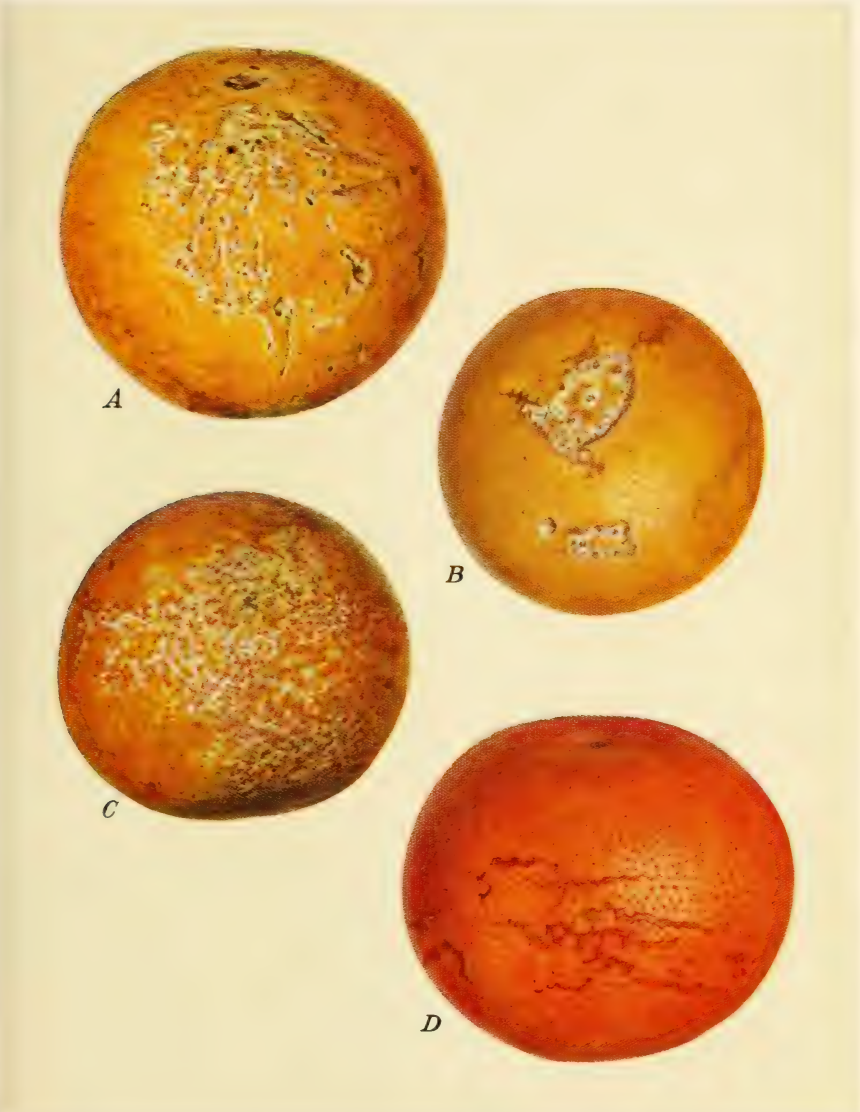
(See *43*.)

PURPLE SCALE

(See Grapefruit, Purple Scale, p. 6, and pl. 3, *C*.)

SCAB

(See Grapefruit, Scab, p. 7, and pl. 1, *D*.)



Nonparasitic injuries of orange: *A*, Thorn injury; *B*, hail injury that occurred early in the life of the fruit; *C*, wind scarring; *D*, leaf scarring.

SCLEROTIUM ROT

(*Sclerotium rolfsii* Sacc.)

A rot seen occasionally on the market on citrus fruits from Florida, Puerto Rico, and Cuba is caused by the soil-inhabiting fungus *Sclerotium rolfsii*. The decay on grapefruit and lemons is yellowish green, slightly darker than normal, whereas on oranges it is dark brown with slightly lighter margins. At room temperature the decay spreads rapidly through the entire fruit and if the air is moist, extensive white, fluffy mycelium forms on the surface. In and on this mycelium many spherical sclerotia one-sixteenth inch or less in diameter are found. They are yellow at first, changing to deep brown.

Because the causal fungus is a soil inhabitant, fruits touching the ground are usually the only ones affected. However, the decay may spread from a decayed to a sound fruit during transit if the shipment is moved without refrigeration. If the disease is prevalent in the grove, fruits touching the ground should not be packed.

(See *43*.)

SEPTORIA SPOT AND STAIN

(Probably *Septoria citri* Pass.)

Spots or pits caused by a species of *Septoria*, probably *S. citri*, sometimes occur on lemons, grapefruit, and Valencia oranges in California. The pits seen on fruit on the tree are usually not over one-twelfth of an inch in diameter and do not extend below the oil glands (pl. 15, *B*). Later they may enlarge to deeper pits one-eighth to three-eighths of an inch in diameter. The smaller pits are light tan to buff-colored and are surrounded at first by a green area that eventually turns reddish to reddish brown. The larger pits may become dark brown or even black.

Occasionally the small pits occur in a pattern known as septoria stain, which is somewhat suggestive of melanose tearstaining on Florida citrus fruit (see p. 5).

Septoria spot and stain is rarely seen on the market and usually is of only minor importance in the grove.

(See *43*.)

SPOTTING AND SCARRING

Oranges arriving on the market show at times various kinds of spotting, which are usually hard to relate to a definite cause. Most of the spots are brown, some are purely superficial, others are more or less sunken, and all are roughly circular in outline. Descriptions and illustrations of such spots have been published at various times, assigning as the causes: Fumigation injury; tree freezing; fungus attack; localized physiological break-down; hail injury (pls. 17, *B*, and 16, *D*); and wind and leaf scarring (pl. 17, *C* and *D*). These are all causal agencies, the results of which have been observed and authenticated.

Some of the spots are described and illustrated in this publication. (See Fumigation Injury (p. 28), Pitting (p. 5), and Aging (p. 18).) The difficulty, from the market point of view, is that in many instances the history of the fruit is not known and cannot be obtained; so definite diagnosis of the cause cannot be made.

(See *43*.)

SPRAY INJURY

If oil emulsions, either alone or in combination with bordeaux mixture, are sprayed too heavily on citrus fruits or if the emulsion has not been well made, they are likely to injure and spot the skin. Bordeaux-oil injury is usually a splotchy, superficial russet, rarely penetrating below the epidermis and rarely causing pitting (pl. 11, *C* and *D*). Oil-spray burn is more deep-seated, usually occurring as a depression like a large pit where the last drop dried or where the rind was exposed to the full rays of the sun.

Lime-sulfur sunburn on Florida fruit occurs for the most part in late summer after the rains have slackened and following applications for citrus rust mite control. Grapefruit and Hamlin and other early oranges are very susceptible (pl. 6, *D*). The blemish is found mostly on the exposed surface of fruit on the southwest part of the tree. The affected parts are slightly sunken with an abrupt margin having an irregular outline. The epidermal cells are killed, first turning gray, and later may crack and become invaded by fungi that produce dark pimples on the gray surface tissue. The spots vary in size from three-eighths to one inch in diameter. Decay ordinarily does not set in at these points unless the fruit is held a long time. In such cases *Phomopsis*, *Diplodia*, or *Colletotrichum* may be the invader. (See also Grapefruit, Sunburn, p. 9.)

An injury somewhat similar to the type just described and also caused by lime-sulfur burning occurs on citrus fruit from other regions. In addition, another kind of lime-sulfur injury has been observed in California (*43*), characterized by hard firm brown spots with gum pockets underneath in the white portion of the rind. This spotting is reported to occur most often on lemons in the coastal sections, and usually on fruits facing the interior of the tree.

(See *43*.)

STEM-END ROT

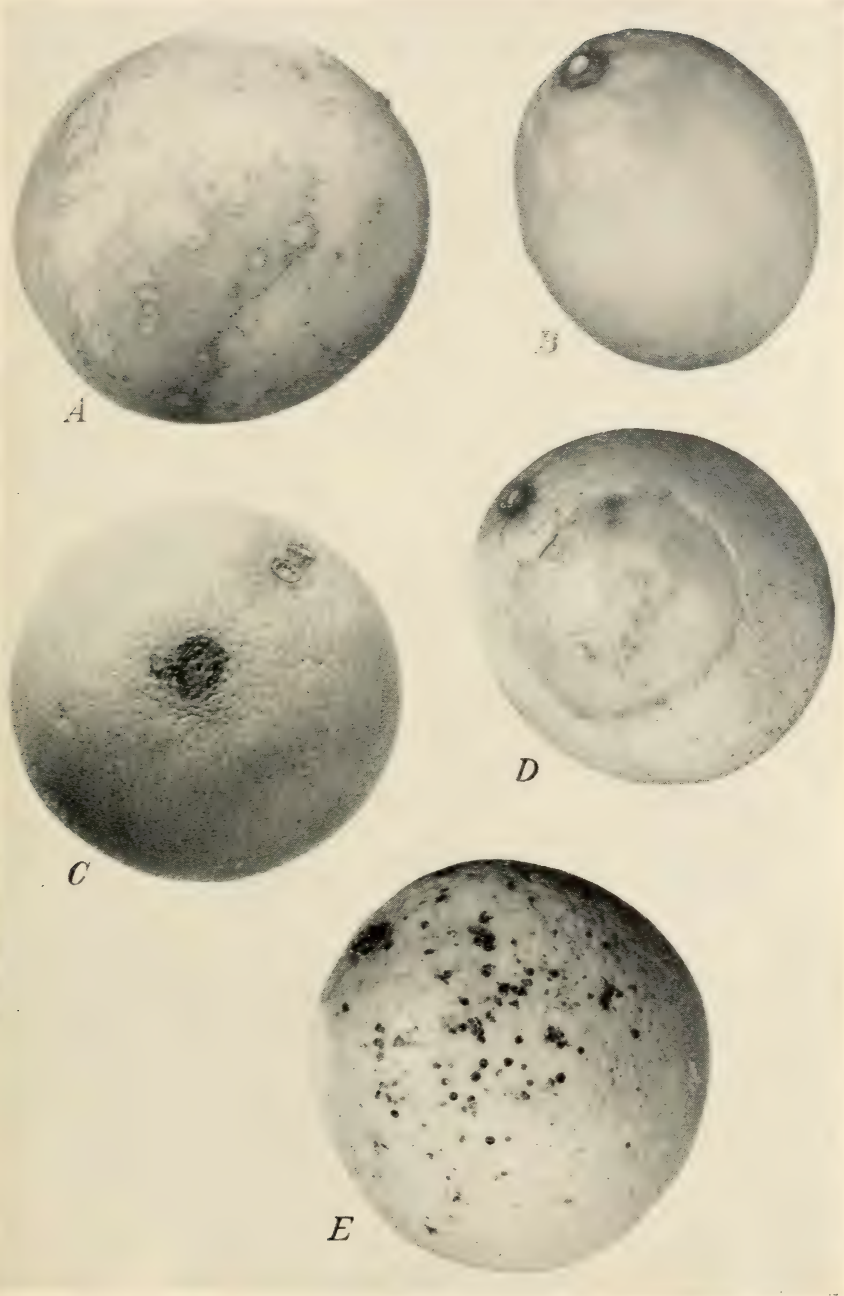
(See Grapefruit, Stem-end Rot, p. 7, and pls. 5, *A*, and 6, *A*.)

STYLAR-END ROT

(*Alternaria* sp. and *Fusarium* sp.)

Stylar-end rot, commonly known as blossom-end rot, occurs on oranges, and to a less extent on grapefruit, in Florida and the West Indies. The disease is apparently due to physiological factors, probably unfavorable weather and soil conditions, which bring about a weakened condition of both tree and fruit, slight cracking of the rind at the stylar end, and eventually infection at the cracks by various fungi. The first prominent symptom of the rot in affected fruits may be any one or various combinations of the following: (1) A reddish-orange color over most of the surface, developing several weeks ahead of the normal yellowish orange color of the main crop; (2) a slightly softened condition over an area half an inch or more in diameter, at the stylar end, sometimes accompanied by browning at the center of this area, and (3) a slight yellowing at the blossom end, with or without browning at the center.

When fruits showing these symptoms, especially the high color, are cut lengthwise, they are usually found to be diseased on the inside, the



A, "Thrips injury," probably caused by rubbing, on Florida orange; *B*, thrips injury on lemon; *C*, orange tortrix injury; *D*, grasshopper or katydid injury on orange; *E*, Florida red scale on orange.

diseased condition manifesting itself as a gray, pink, or black discoloration and a partial decomposition of the pithy core. On the other hand, fruits showing merely splitting and a brown spot or even a slight softening at the stylar end are often found perfectly sound inside when cut (pl. 13, *E*). The colors mentioned are apparently due to the action of specific fungi, since *Alternaria* is always associated with the gray or black color and *Fusarium* with the pink. Nothing is known of when or how these fungi gain entrance into the fruit, but it seems probable that they enter early in the life of the fruit, just as in the case of black rot of California navel oranges.

In advanced stages the rind at the stylar end becomes decayed in areas of varying size up to 1½ or 2 inches in diameter, and like the affected tissues on the inside shows a gray, pink, or black color. The symptoms on grapefruit are practically the same as those on oranges except that the extreme final stages of decay occur only rarely if at all.

There are indications from holding and shipping tests that the rot continues development in transit, though rather slowly. Nothing is known of methods of control. Observations in Florida indicate that most of the affected fruit either falls or is picked off by January 1; hence the rot is not likely to be of importance either in the packing or on the market after that date.

(See *33*, *43*.)

THORN INJURY

Injuries due to thorn punctures are often found on all kinds of citrus fruit from all producing regions. When deep and well marked, such injuries can hardly be mistaken for anything else. When shallow they sometimes resemble bruises (pl. 17, *A*).

Infection with decay-producing organisms may follow but is not common.

THRIPS INJURY

(The citrus thrips, *Scirtothrips citri* (Moulton), in California, and the Florida flower thrips, *Frankliniella bispinosa* (Morgan), in Florida.)

The damage done by thrips to citrus trees and fruit is caused by the feeding of both adults and larvae upon the surface of the parts attacked. Feeding may be done on both young and nearly mature fruit and on new and tender foliage.

In California and Arizona thrips injury is of most importance on oranges and, in its most characteristic form, occurs as a roughened gray band or ring at the stem end (pl. 15, *E*). Occasionally more or less irregular and indefinite roughened areas occur on other parts of the fruit. Navel oranges are more frequently affected than Valencias. Grapefruit, lemons, and tangerines are also attacked.

True thrips injury is rare on Florida citrus fruit. The blemish commonly called "thrips injury" on Florida fruit is now believed to be merely the result of rubbing against leaves and twigs during late winter or early spring while the fruit is young and small (pl. 18, *A*). It has been found, for example, that when an orange tree was screened against wind the so-called thrips injury did not develop; and, conversely, that on trees not so protected it did develop. Thrips were present in large numbers on both the screened and the unscreened trees.

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Thrips marks on California fruit may be fairly smooth, affecting the shape and texture only slightly, but in severe cases they may affect both the shape and the texture severely.

The adult citrus thrips (*Scirtothrips citri*) averages less than a twenty-fifth of an inch in length and is pale orange yellow; hence it is not easy to see. It overwinters in the egg stage, and several broods may be produced during the summer. There are no striking differences between the effects produced by citrus thrips and those produced by the Florida flower thrips (*Frankliniella bispinosa*).

(See *94*, *100*, *131*, *132*.)

TRICHODERMA ROT

(*Trichoderma viride* Pers. ex Fr.[8])

Trichoderma rot is seen occasionally on oranges and lemons from storage. It has been reported in the United States, Italy, South Africa, and Southern Rhodesia. The decay at first affects only the rind, causing it to turn light brown although it remains firm. It later turns the rind dark grayish brown and spreads into the interior of the fruit causing it to become soft and spongy. Decayed tissue has a definite coconutlike odor. Clumps of white mycelium form on the larger decayed areas, and these produce cushions of powdery green spore masses. Because of this color the decay may be confused with blue mold rot (p. 19). It is, however, much firmer than blue mold rot, develops more slowly, and bears fewer spores on its surface.

The causal fungus, *Trichoderma viride*, is usually considered a soil-inhabiting saprophyte. It has been reported as a parasite on other soil fungi. Apparently it usually enters the fruit through injuries in the rind; so control measures used for blue mold rot (p. 21) should also prevent trichoderma rot.

(See *42*, *43*, *50*, *91*.)

WATER SPOT

Water spot is a disease that develops in California on mature Washington Navel oranges on the tree, following exposure to 2 or 3 weeks of rainy or foggy weather. In its earliest stage it occurs as a minute cracking of the cuticle, usually near the navel, caused by a swelling of the underlying tissue when it absorbs water (pl. 10, *B*). It also develops on the shoulder of the fruit, where drops of water may easily collect, and at or near wounds. If the wet weather continues these affected areas enlarge, assume a water-soaked appearance, and are eventually invaded by decay organisms, chiefly green mold or blue mold (pl. 10, *C*). Under extreme conditions half or more of the fruit on a tree may be ruined by this rind break-down and the rot that follows (pl. 10, *D*). Water spots that develop elsewhere than at the navel usually start at bruises or skin breaks.

If the weather turns dry after the first stage of the spots has developed, the water-soaked areas become brown, dry, and slightly sunken, and active decay of the fruit is prevented. However, some of the blemished fruit may escape notice during the harvesting and packing operations and so get into the packed boxes. It may also happen that the spots are invaded by fungi but are kept from decaying

[8] Perfect stage, *Hypocrea rufa* Fr.

by the coming of dry weather. When such fruit reaches the packing house much of the external fungus growth is removed by the brushes and again the damaged fruit may be packed along with sound fruit. In either of these cases the spots become a potential source of trouble during transit and on the market, because of the danger of renewed growth of the fungi through the weakened rind whenever conditions become favorable.

Water spot is found in highest percentage in groves sprayed with oil, except where the spray mixture consists of miscible oil and lime-sulfur. On trees where this combination is used and on trees given other spray treatments, water spot develops in comparatively small amounts only. When weather conditions are favorable the spot may be expected from about the middle of January to the end of the navel orange season.

(See *35*, *36*, *43*, *48*.)

WATERY BREAK-DOWN

(See Grapefruit, Watery Break-down, p. 10.)

OTHER SUBTROPICAL FRUITS

Avocados

ANTHRACNOSE (BLACK SPOT)

(*Colletotrichum gloeosporioides* Penz.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Anthracnose, or black spot, is the most frequently observed rot of softening avocados on the market. It occurs on fruit from all commercial-growing sections and is found on all commercial varieties.

Spots appear over the surface of the fruit as small light-brown, circular discolorations of the skin. They enlarge very rapidly, and the color changes through dark brown to black in the center of the spot. Usually a light-brown border of fresh decay can be seen surrounding the dark central portion. A single lesion may cover the entire side of a fruit or scattered lesions may coalesce to cover even larger surface areas. These large decayed areas are found only on overripe fruit. If the fruit is in a moist atmosphere pink waxy spore masses are formed on the spots in masses or as a covering. These turn black with age.

The decay penetrates deeply into the flesh, eventually extending to the seed in the form of a hemisphere. The decayed tissue is firmer than the surrounding flesh and is easily separated from it, leaving a fairly clean cavity. Immediately beneath the center of the spot the flesh is black, but this color fades at the edges into a shade of tan only slightly darker than the healthy flesh.

CAUSAL FACTORS

The causal fungus, *Colletotrichum gloeosporioides*, also causes anthracnose decays of mangoes (p. 45) and citrus fruits (p. 3). It attacks leaves and twigs of the avocado, from which organs the spores are washed onto the fruit. The fungus is weakly parasitic, attacking only ripe fruits and requiring openings or breaks in the rind to gain entrance. On Florida fruit it very commonly enters through blotch lesions.

CONTROL MEASURES

Control of the decay is effected chiefly by preventing skin breaks in the fruit. The fruit should be clipped instead of pulled from the tree and should be handled carefully during all marketing operations. In Florida three applications of bordeaux mixture to the tree as recommended for the control of blotch will also effectively control anthracnose. It is probable that the effect of these sprays on anthracnose is chiefly due to preventing openings in the skin caused by the blotch fungus.

(See *63*, *67*, *82*, *97*, *113*, *115*, *116*, *145*.)

BLOTCH (CERCOSPORA SPOT)

(*Cercospora* sp., probably *C. purpurea* Cke.)

Blotch, or cercospora spot, has been reported chiefly from Florida, but, because it appears only as a surface blemish and frequently in connection with anthracnose, it may have been overlooked in the West Indies and South America. In Florida it is widely distributed over the avocado-producing districts and constitutes one of the important diseases of this fruit.

The disease appears on the foliage, fruit, and young stems. On the leaves the lesions are angular and brown to dark brown. They are usually scattered but may coalesce to form large brown areas. In severe cases the leaves drop prematurely.

Blotch is apparently capable of attacking the fruit at any stage of its development on the tree. At first the spots appear as greenish-white dots that slowly develop into small, irregular, slightly sunken, hard, surface blotches. Their color is brown or dark brown except in the center of the spot, where frequently a small white tuft of the causal fungus is visible. The surface of the spot is usually cracked and fissured.

On the fruit, blotch is a surface blemish only, never penetrating the flesh. Because the spots crack and expose the flesh beneath they open the way for decay by secondary organisms, particularly by *Colletotrichum*, which commonly accompanies blotch on mature fruit. It has been found that if blotch is controlled, little trouble is experienced from anthracnose.

The species of *Cercospora* that causes blotch apparently lives over from one season to the next on infected leaves.

Blotch can be controlled by proper application of bordeaux mixture. It is necessary to apply the fungicide at least three times at monthly intervals beginning in early May. For varieties maturing in late winter and early spring an additional application in early September should be made.

(See *113*, *116*, *145*.)

DOTHIORELLA ROT

(*Dothiorella gregaria* Sacc.[9])

Dothiorella rot of avocados is important only on fruit from certain coastal districts in California. The decay usually does not affect fruits

[9] Perfect stage, *Botyrosphaeria ribis* Shear, Stevens, and Wilcox.

until they begin to soften. It appears first as small, umber-colored, nondepressed, vaguely bounded firm spots usually centering at a speckle or other blemish. It may reach a diameter of one-half inch in 3 or 4 days at which stage it becomes slightly sunken, and a watery rot with no definite boundaries spreads rather slowly into the flesh. The decaying flesh has a rancid unpleasant odor that penetrates the sound tissues of the fruit.

The fungus also affects leaves and twigs on which it is carried over from one season to the next. Pruning dead twigs from the tree and spraying with a bordeaux and sulfur mixture have been recommended for control of the disease.

(See *67*, *68*, *116*.)

FLESH DARKENING

Avocado fruits of different varieties vary in the normal color of their flesh. In certain varieties the flesh is sometimes rather gray, and during certain seasons, possibly because of abnormal conditions of growth, the flesh of the commercial varieties may be unusually dark. The flesh may also darken in overripe or very soft fruit or when the seed begins to grow. On the market hard, dark areas are sometimes found in fruit from Florida and the West Indies which is believed to have grown on seedling trees.

Flesh discoloration is also commonly caused by chilling or freezing the fruit. In general it occurs when the fruit is held below 40° F., although certain varieties can withstand storage temperatures as low as 37° without injury. Avocados of the West Indian race are more susceptible to chilling injury than those of the Guatemalan and Mexican races.

In slight chilling injury only the tissues of the fibrovascular strands may be darkened. After more severe chilling the skin takes on a brown or scalded appearance and the flesh, particularly around the base of the seed, becomes a gray color which changes to brown as injury increases. Badly chilled fruit fails to soften normally when subsequently held at room temperatures. Fruits just beginning to soften are more susceptible to chilling injury than green or riper fruit. Fully softened fruit may be held at 32° without injury.

The average freezing point of a number of varieties of avocado fruits has been reported as 27.2° F. Immature and partially mature fruits may freeze at a slightly higher temperature. If the fruit freezes before it softens, the flesh becomes penetrated by many small cracks and remains tough and rubbery.

(See *31*, *67*, *77*, *83*, *84*, *85*, *126*.)

RHIZOPUS ROT

(*Rhizopus nigricans* Ehr.)

Rhizopus rot is the most rapidly developing decay of ripe avocados at room temperature. It is not found on the fruit until it begins to soften but is fairly common on roughly handled fruit ripened at high temperatures. The decayed area is extensive, dark brown and, if the atmosphere is moist, is covered with coarse white to gray mycelium bearing the typical spherical black sporangia. If the atmosphere is dry, little mold growth will occur and the sporangia will be borne on

short tufts in depressions or breaks in the skin. Decayed tissue is collapsed and watery but is held together by the tough mycelial threads of the fungus. These can be detected with the tongue when the tissue is tasted. Affected fruits usually become cracked and exude an amber-colored liquid.

Rhizopus nigricans, the causal organism, also produces soft rots in peaches, strawberries, and a number of other fruits and vegetables. In avocado fruits it enters at skin breaks or at the stem scar if the fruit has been pulled from the tree. The fungus develops most rapidly at temperatures between 70° and 85° F. At 50° there is little danger of new infections being initiated and at about 45° development ceases altogether. Control measures consist of careful picking and handling of the fruit to avoid injuries to the skin and of cooling of the ripe fruit to 50° or lower.

(See *67*.)

SCAB

(*Sphaceloma perseae* Jenkins)

OCCURRENCE, SYMPTOMS, AND EFFECTS

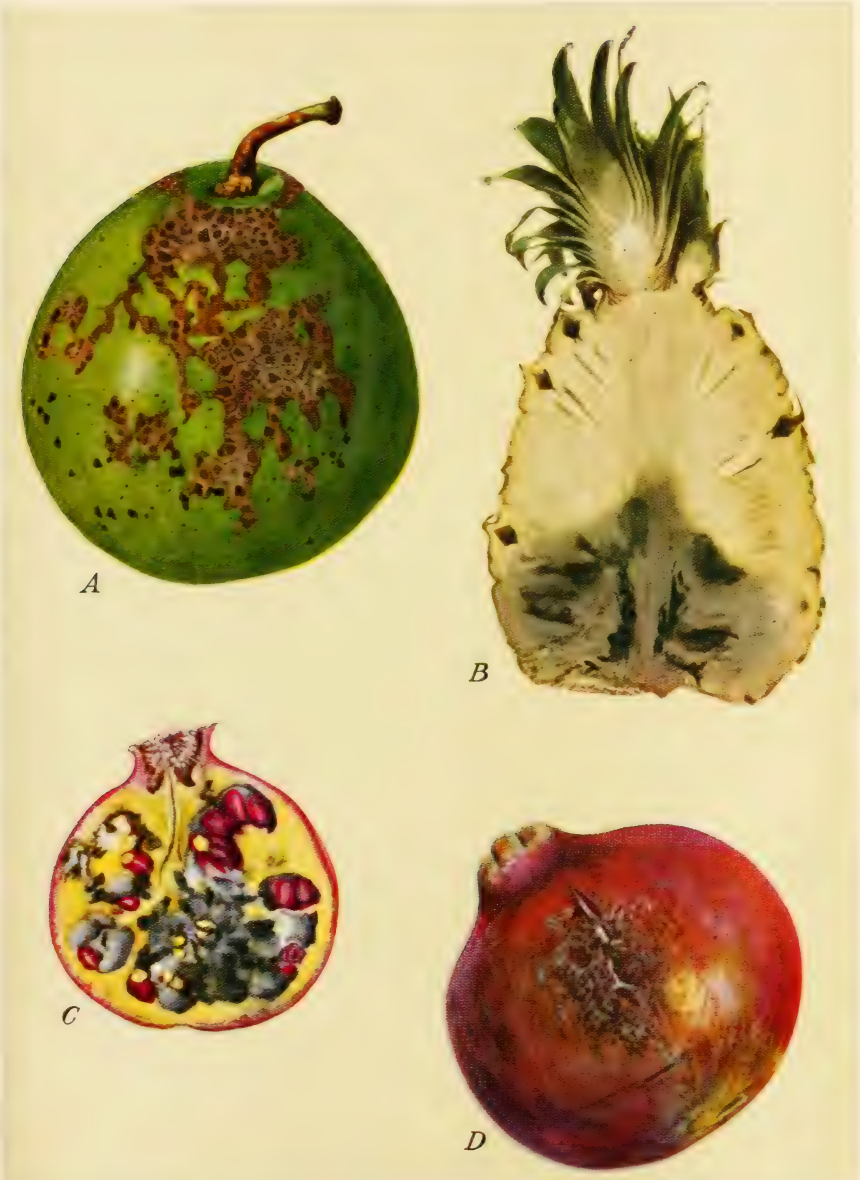
Scab is one of the most important diseases of the fruit and foliage of the avocado in Florida, Mexico, and the West Indies but has not been found in California or in the Hawaiian Islands. It is apparently able to attack most of the commercially grown varieties, the Fuerte, Lulu, Trapp, and Taylor being especially susceptible.

The disease is very common on foliage of young plants in the nursery. Spots on the leaves are small, circular to irregular in outline, and purplish brown to almost black. On the twigs, leaf petioles, and young shoots, the spots are oval and appear darker and more elevated than those on the leaves. The disease on the fruit occurs as oval, raised spots like those on the twigs. Frequently the spots coalesce into a large russeted or corky tan area with irregular boundaries (pl. 19, *A*). As the fruit enlarges these areas crack into angular divisions suggesting somewhat the pattern on a turtle's back. During the first month of their development the lesions on the fruit are covered with a dense velvety dark-olive conidial growth. This covering gradually weathers away until on a mature fruit only a narrow border of the fungus is present in an occasional lesion. The presence of the dark border of fungus on some of the spots and the irregularity of the edges in the coalesced spots are helpful in distinguishing scab from the corky areas produced by limb rubs.

Severely affected fruits are usually undersized and misshapen, but otherwise scab occurs only as a surface blemish of the fruit and rarely is the means of entry for decay-producing organisms. It does not develop or spread in transit and storage.

CAUSAL FACTORS

The causal fungus *Sphaceloma perseae* for many years was considered identical with the citrus scab organism, but eventually they were recognized as distinct. The critical period for infection seems to be from the time the bloom drops until the fruit is 6 or 8 weeks old.



A, Scab on avocado; *B*, black rot on pineapple; *C*, alternaria rot on pomegranate; *D*, sunburn on pomegranate.

CONTROL MEASURES

For the control of avocado scab, spraying with bordeaux mixture is recommended.

(See *70*, *113*, *115*, *116*, *145*.)

BANANAS

ANTHRACNOSE

(*Gloeosporium musarum* Cke. and Mass.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Anthracnose occurs in all parts of the world where bananas are grown. It is occasionally destructive to banana plants in the field but is usually confined to the fruits and does very little damage even to them except when they are ripe. Although the disease may develop on bananas in transit from the Tropics and in ripening rooms at terminal markets, it is not usually important as a cause of decay and waste until after the fruit has passed into the hands of the retailer and the consumer. Many so-called overripe bananas in grocery and fruit stores are merely in an advanced stage of anthracnose, at least so far as the skin is concerned.

Anthracnose may develop first on the short stems by which the individual bananas are attached to the main stalk, and it spreads from them to the adjacent peel at the attached end of the fruit. At such places it shows as a brown discoloration, which slowly darkens to black as the affected areas enlarge. The disease may also appear on any part of the peel, first as very small brown spots and later, when these enlarge and darken, as black spots an inch or more in diameter. If the fruit is held for a considerable time after ripening, the spots may coalesce so completely that all of the peel becomes diseased and blackened. Eventually there is noticeable decay of the edible portion of the fruit. Tip rot caused by *Gloeosporium* develops in ripening rooms when the fruit begins to turn yellow, its occurrence there being the result of a spreading of the fungus from diseased flower remnants to the adjacent peel.

Under conditions where the air is moist and the temperature fairly high, decayed spots on bananas take on a whitish, hoary appearance, with the black color showing through. This condition is produced by a superficial growth of the anthracnose fungus and is one of the most characteristic symptoms that the disease exhibits.

At about the time when blackening occurs, sometimes earlier, the affected areas begin to show a pink color, due to the production of pink masses of spores. On large spots it frequently happens that only the younger spore masses around the outside are pink while the older ones toward the center are gray or even black.

The only condition with which anthracnose is likely to be confused is the blackening caused by bruises. The two can usually be distinguished, however, by noting the presence or absence of the symptoms described above, i. e., pink spore masses, a superficial growth of white mold, and decay extending into the edible portion of the fruit.

CAUSAL FACTORS

Banana anthracnose is caused by the fungus *Gloeosporium musarum*, which is represented by a number of different strains in different

regions of the Tropics. All parts of the plant may be affected except possibly the roots, but as already stated the chief damage is done to ripe or nearly ripe fruits. Among the factors favoring infection the most important are high temperature, high humidity, the presence of bruises or wounds, and the degree of maturity of the fruit. There are differences in varietal susceptibility, but these are of little significance on the markets of the United States since banana imports into this country consist almost exclusively of one variety, the Gros Michel.

CONTROL MEASURES

Careful handling of the fruit throughout the marketing process is of the utmost importance in controlling anthracnose. It is also important to clean out ripening rooms frequently and to treat the walls and floor with some disinfectant. The practice of putting hay or sawdust on the floor is an unsafe one, for if such material is allowed to remain indefinitely it becomes contaminated with banana refuse and is then a source from which spores may spread to healthy fruit placed in the room.

(See *4*, *120*, *123*, *128*, *129*.)

CHILLING INJURY

If green bananas are exposed to temperatures below about 56° F. they are in danger of damage from chilling injury. The actual occurrence of injury and its severity depend on how long the fruit is exposed to the chilling, on how low the temperature goes, and to a large extent on the character of the fruit. The less mature fruit is very sensitive to cold and is injured by exposure to temperatures close to 56° for only 4 or 5 days; more mature fruit is more resistant and will stand a temperature of 53° to 56° for 10 or 11 days without injury.

The first visible symptom of chilling injury is the development of a dull yellow color instead of a healthy bright one. Frequently there is a fine brown streaking in the skin, which is the result of changes in the mucilage ducts. In severely chilled fruit the skin becomes brown all over and eventually turns black. Chilled fruit is easily discolored by the slightest bruise.

Slight chilling seems to produce only surface injury because it has been found that in bananas showing the milder symptoms just described, the ripening of the pulp proceeds at a normal rate after the fruit has been brought to a temperature favorable for ripening. Severely chilled fruit does not ripen properly and consequently has poor flavor. No treatment subsequent to chilling can improve color. Slightly chilled fruit can be marketed, but it should be ripened and used as quickly as possible.

If green healthy bananas are broken or cut, a milky, glutinous juice (latex) exudes freely, chiefly from the skin and to a slight extent from the pulp. In chilled fruit this exudation of latex does not occur. Its absence, however, is not a sure indication of chilling injury, because latex exudes very little if at all from the peel of turning or ripe fruit.

(See *127*, *128*, *129*, *130*.)

FRUIT SPOT

OCCURRENCE, SYMPTOMS, AND EFFECTS

The term "fruit spot" or "flecking" is used to refer specifically to a disease of bananas that is of minor importance in producing regions but may develop to a serious extent during transportation and in the ripening room. The disease has been reported from several countries in the American Tropics and from various other parts of the world. Because of its regular occurrence at certain seasons of the year and its damaging effect on the appearance of the fruit when the spots are numerous, the disease is regarded by importers as economically the most important disease of its kind to which bananas are subject (*72*).

The spots as they appear on green fruit in the field in Central America (*72*) are circular or nearly so, reddish brown or black, and surrounded by a green halo. The mature fruit spots, also called transportation spots because they may develop on the fruit during transit to market, are identical with the field spots in appearance. The ripening spots develop only after the fruit has begun to turn yellow or after it has been held in the green condition for an undue length of time under ripening conditions. Some of the spots may be similar to the mature fruit spots except for the green halo; others may develop as irregular brown pits or tiny rust-colored specks.

In the field, spots commonly occur on the inner faces of the fingers and between fingers. On mature fruit the spots may develop over the side of the bunch away from the banana plant but are usually most abundant toward the tips of the fingers and especially on the upper hand or hands as the bunch hangs on the tree. They also occur between fingers and especially on the inner faces of the topmost hands as they occur on the tree. If they develop in transit their location is about the same as that just described. Spots on ripening fruit are most abundant toward the tips of the fingers, especially on the inner faces of the upper hands.

The spotting is heaviest in the early part of November and increases somewhat again in July, chiefly during transportation from the Tropics. By the middle of August the increase during ripening becomes serious, whereas the increase during transportation may be less important.

CAUSAL FACTORS

This type of fruit spot is apparently a nonparasitic or physiological disease. Fungi sometimes occur in older or ruptured spots, but they cannot be found in younger ones. Field studies have not shown any consistent relation between insects and fruit spot. The season of most severe spotting coincides roughly with the season of heavy rainfall, high humidity, and low evaporation, which is also the time of year when concentrations of nitrates are low in the soil. These are the conditions under which the activities of the banana plant are lowest, but what relation there may be between that fact and the development of fruit spotting is not thoroughly understood.

(See *72*, *73*.)

CONTROL MEASURES

Suggestions for avoiding loss from fruit spot include rejection of medium or heavily spotted fruit in the Tropics and at port of discharge

when shipments are being made up for transportation to interior points.

(See *72, 73.*)

Figs

ALTERNARIA SPOT

(*Alternaria tenuis* Nees)

Alternaria tenuis is the cause of a spotting of figs that often detracts greatly from their market appearance and value. It is found on all the important varieties and on fruit from both the Atlantic and the Pacific coasts of the United States.

The disease is first evident as a surface growth of small, grayish-white tufts of mycelium. The mycelium soon darkens to an olivaceous color or even darker, and the spots may enlarge to a diameter of one-quarter or one-half inch. At first the fungus appears to have but a slight attachment to the skin and sometimes can be rubbed off with little evidence of injury, but as the spots enlarge and the tissue beneath becomes slightly sunken, any attempt to remove the fungus also removes the skin.

Alternaria spotting may occur on fruit that is still on the tree but is more common on that which is in transit or held at the cannery or on the market. The disease is confined largely to fully ripe fruit, and the fungus is favored by cracks in the skin and by the sugary solution often found on the surface of figs.

High humidity tends to increase spotting, but storage at low humidity may cause an undesirable shriveling of the fruit. Low temperature offers the best means of controlling alternaria spotting. Figs that are promptly precooled after harvest and kept at a temperature of 45° to 50° F. in transit are not likely to become seriously affected during the usual marketing period. In the absence of precooling facilities initial carbon dioxide treatments reduce the activity of the fungus to about one-third of normal.

(See *25.*)

BLACK MOLD ROT

(*Aspergillus niger* Van Tiegh.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Black mold rot of figs, often erroneously called "smut," is found on figs on the tree and in the drying yard and also occurs in the packed product. It has been reported only from Georgia and California and so far as known affects chiefly the white varieties, such as Calimyrna and Adriatic. The black Mission and Kadota (a white variety) are much less commonly affected.

The disease on fresh figs is characterized by a dirty white to slightly pink color of the skin and pulp of affected fruits and a firm to finally a cheesy consistency of the pulp. A mass of white mycelium develops within the fig and eventually cavities are formed that become lined with the black spore masses of the fungus. Infection varies greatly in severity. If severe it gives the fruits a dark translucent appearance by which they are easily identified; if infection is light, it may produce merely dark or yellowish spots in the pulp, with no spores. Fruits in

this condition show no signs of the disease on the outside, are difficult to eliminate during the packing process, and consequently may sometimes reach the market. Badly "smutted" figs, when squeezed, give off from the eye a black cloud consisting of the spores of the fungus.

CAUSAL FACTORS

Black mold rot is caused by the fungus *Aspergillus niger*. The same species causes the black mold rot of onions and a decay of the fruit and fruit stems of grapes. The fungus is widely distributed in nature and is undoubtedly common on the soil surface and on vegetable debris; it has also been found to live over from one season to the next on the small twigs of fig trees. Infection is brought about by spores carried through the eye of the fruit to the interior by ants, fruit flies, and varicus beetles. Such insects are able to make their way into figs so green that the eye still appears closed; they enter more easily of course when the eye has begun to open, as in figs that are mature but still unshriveled. Observations in the orchard show that most of the natural infections occur in fruits that are in this condition. In figs fully mature and shriveled, the sugar content of the pulp is so high that the fungus cannot grow.

CONTROL MEASURES

Most of the infection takes place while the figs are still on the tree. Some of it, however, seems to take place after the fruit has fallen, especially if too long a time is allowed to elapse before it is picked up. Naturally, under such conditions, greater opportunity is given for the entrance of insects and the consequent introduction of the fungus spores. More frequent pickings, certainly much oftener than once every 2 weeks as sometimes happens, would prevent at least a part of the "smutting" and would at the same time give a cleaner, better appearing product. No methods are known by which the fruit can be kept free of the disease while still on the tree.

(See *34*, *56*, *66*, *86*, *88*, *107*.)

BLUE MOLD ROT

(*Penicillium* sp.)

Blue mold rot, caused by *Penicillium* sp., is sometimes found on fresh figs on the market. Its development is relatively slow and the affected tissues are only slightly softened. The disease is readily recognized by the blue-green color of the fungus growth.

CLADOSPORIUM SPOT

(*Cladosporium herbarum* Lk. ex Fr.)

Cladosporium herbarum is the cause of occasional spotting of figs. The spots appear first as dark olive-green specks that are particularly noticeable on light-skinned varieties. As they enlarge they become slightly depressed and finally turn to a yellowish-olive color. The spots are found chiefly on overripe figs and are not of economic importance.

Methods of control are the same as recommended for alternaria spot (p. 42).

(See *25*.)

GRAY MOLD ROT

(*Botrytis* sp.)

Botrytis sp. sometimes causes considerable loss of figs on the market. The fig tissue is softened, there is some leakage of juice, and a growth of gray fluffy or velvety mycelium spreads over the surface. The disease occurs chiefly on overripe fruit.

Prompt refrigeration after harvest, at 40° to 45° F., greatly retards although it does not entirely prevent the growth of the fungus.

(See *25*.)

RHIZOPUS ROT

(*Rhizopus* sp.)

A rot caused by *Rhizopus* sp. has been found occasionally on fresh figs on the market and has been reported from Louisiana and California as attacking figs while they are still on the tree. The rot is soft and leaky. The skin and flesh of the fig are browned, and the affected area is covered with coarse, grayish mycelium followed by the development of black fruiting bodies.

Rhizopus rot is favored by damp, rainy weather in the orchard and by high temperature and high humidity in transit or on the market. Soft, overripe fruit is particularly susceptible to the disease. Figs that are picked at proper maturity, carefully handled, promptly cooled to 50° F. or lower, and kept cool will not be seriously affected with rhizopus rot during the storage or transit period.

(See *55*.)

SOFT ROT (ENDOSEPSIS)

(*Fusarium moniliforme* Sheldon [10])

Soft rot of figs is characterized externally by water-soaked areas in the skin and a pink or purple color in such areas. These may occur around the eye or may spread out over the sides (pl. 20, *A*). The flesh and pulp underneath them are yellowish brown, disintegrated, and soft and watery, and usually have an offensive odor (pl. 20, *B*). Frequently they are so affected even when the outside of the fruit appears to be sound.

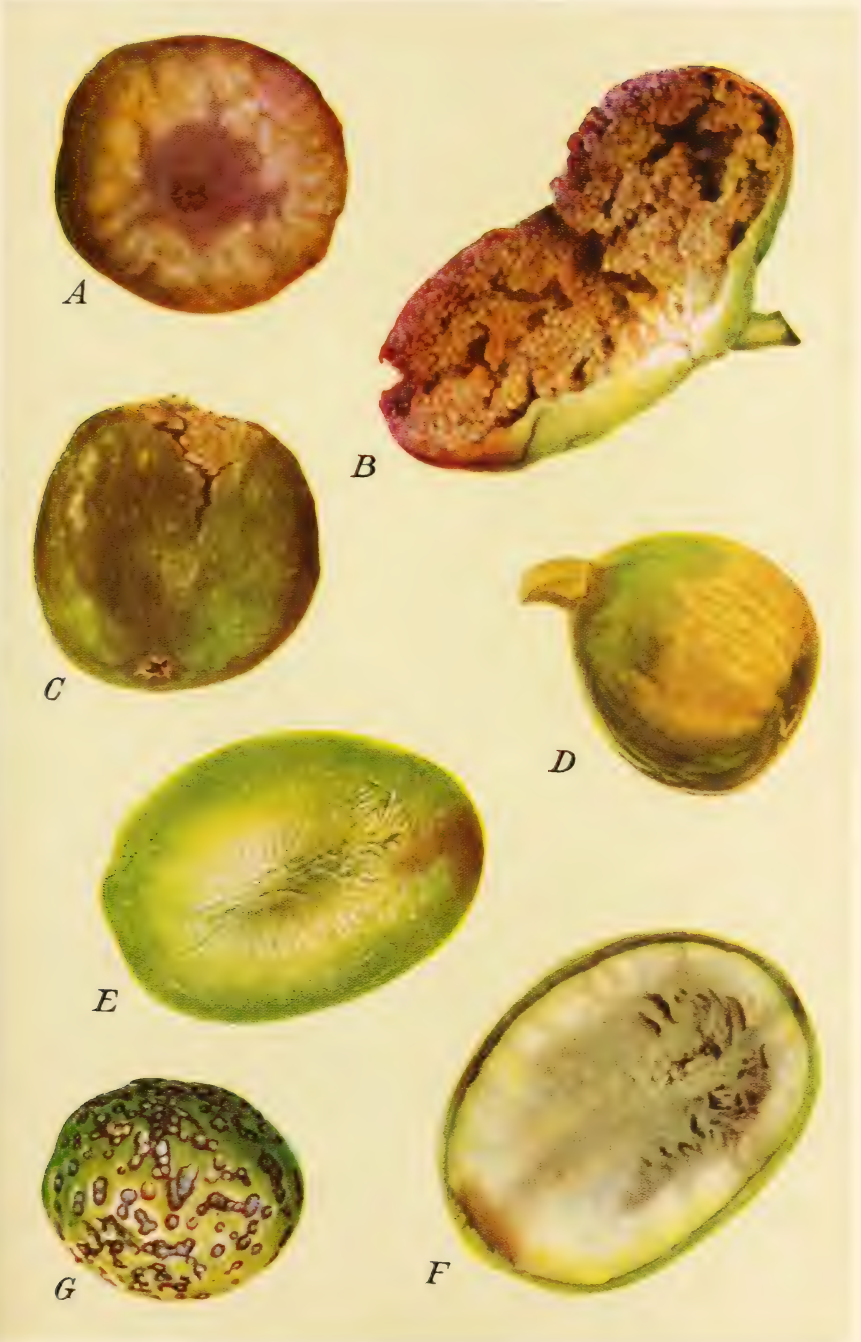
The rot is known at present only in California on caprifigs and on Calimyrna and other edible, caprified varieties; that is, on varieties that do not set fruit unless they are pollinated by the fig wasp, *Blastophaga psenes* (L.). The wasp is the agent by which the infection is spread. Spores of the fungus in caprifigs are carried out of these figs and into those of the edible variety on the body of the female wasp. The fungus grows in caprifigs as well as in the edible varieties but causes most decay in the latter.

The disease has become rather serious during the last few years in California fig gardens, but no estimates of the percentage of fruit affected are available.

To date no methods of control have been developed.

(See *26*, *29*, *30*, *34*.)

[10] Perfect stage, *Gibberella fujikuroi* (Sawada) Wr.



A and *B*, Soft rot of fig: *A*, External view; *B*, internal view. *C*, Splitting of fig. *D*, Sunburn of fig. *E* and *F*, Low-temperature injury of olive: *E*, External view; *F*, internal view. *G*, Sulfur dioxide injury of olive.

SPLITTING

Splitting or cracking at the eye end of the fig is sometimes the cause of heavy losses in the orchard and is occasionally found on the market. The cracks may appear as mere crevices at the side of the eye or may extend so deep that the affected fig is practically split in half (pl. 20, *C*).

The Calimyrna variety is particularly susceptible to splitting. The occurrence of this condition in the orchard appears to be associated with damp weather and a turgid condition of the fruit. It is probable that package pressure and careless handling may contribute to the development of the trouble in transit and on the market.

SUNBURN

During a large part of their life on the tree figs maintain a position that keeps the eye end up, or at least no lower than the stem end. The eye end or at times the side of the fruit is thus the part most exposed to the sun. At maturity the fruit hangs with the eye end down. The result is that sunburn, to which the skin of young fruits seems very susceptible, is usually found on what comes to be, late in the season, the lower part of the fruit.

Sunburn consists of tan to dark-brown bands about one-fourth of an inch wide, encircling the eye, or of similarly colored, irregular blotches or spots one-half to three-quarters of an inch across, on the side of the fruit (pl. 20, *D*). Observations on the market indicate that neither of these is of importance except as a blemish.

MANGOES

ANTHRACNOSE

(*Colletotrichum gloeosporioides* Penz.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Anthracnose, or black spot, is the most important disease of mangoes in regions where this fruit is grown commercially. It develops on all tender parts of the plant and is especially severe on the flowers and flower stems. It has been generally known that wet cloudy weather during the blooming period of the mango often was followed by poor setting of fruit. Only lately has it been shown that this is due chiefly to the killing of flower clusters by anthracnose rather than to poor pollination. Young leaves when attacked wither and dry up. Sometimes only the edges of the leaves are affected. These margins darken, dry, and may fall out, giving the leaf a ragged appearance. The disease produces a withertip of the tender twigs. Black dotlike fruiting bodies of the fungus cover the surfaces of dead leaves and twigs.

Anthracnose usually appears on the fruit only as it ripens. The spots at first appear near the stem end as very small brown areas that enlarge rapidly and become black. In some cases the areas involved are in the form of streaks running down from the stem end. Often the entire surface of the fruit is covered by the coalescing of the spots. The affected areas usually crack and sink slightly. The decay is confined to the skin of the fruit except in late stages when it may penetrate

the flesh in shallow areas. Under moist conditions pink spore masses are produced from fruiting bodies scattered over the lesions.

Except in severe cases the decay affects the edibility of the fruit but little because of its shallow penetration and because under normal conditions the fruit becomes ready for eating before the spots have enlarged. However, the lesions detract markedly from the appearance of the fruit and thereby affect the selling price.

CAUSAL FACTORS

The fungus causing anthracnose is the same one that causes anthracnose of avocado (p. 35), grapefruit, orange, and papaya (p. 47). On the mango tree it sporulates on the dead twigs and leaves from which the spores of the fungus wash onto susceptible parts of the tree. The fruit is more susceptible to penetration by the fungus before it is half grown than after that time, but most of the early infections do not become visible until the fruit begins to ripen.

CONTROL MEASURES

Control of the disease is difficult because of the amount of susceptible tender growth on the tree at all times and because flower clusters, which are most susceptible, are difficult to protect with a fungicide. Bordeaux mixture, 3–3–50 strength with a sticker, applied as the buds swell, in the bloom, and while the fruit is developing, has been found fairly successful for the control of the disease. Because the fungus establishes itself in the skin early, fungicidal washes applied to the fruit at picking time are of no value in controlling the disease.

(See *7*, *31*, *79*, *82*.)

Olives

LOW-TEMPERATURE INJURY [11]

Low-temperature injury of fresh olives consists of a browning of the flesh, which begins to develop after about 1 month's storage at 32° to 40° F. (pl. 20, *E* and *F*). In early stages it can be detected only by cutting the flesh, but after prolonged storage it is readily apparent without cutting. Severely affected olives appear water-soaked when cut (pl. 20, *F*).

The browning develops only slightly, if at all, in olives held at 50° F. but becomes progressively worse as the storage temperature is lowered. At 50°, shriveling is a serious factor if the relative humidity is low.

SULFUR DIOXIDE INJURY

Sulfur dioxide injury of fresh olives is characterized by sharply sunken bleached areas that vary in size from mere pin points to areas an eighth of an inch in diameter or sometimes slightly larger (pl. 20, *G*). They result from the placing of olives in a car or storage room with grapes and then fumigating the space with sulfur dioxide. So far as known, they are not subject to invasion by decay-producing organisms.

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[11] Pentzer, W. T. Unpublished notes on file in the Bureau of Plant Industry, Washington, D. C.

Papayas

ANTHRACNOSE

(*Colletotrichum gloeosporioides* Penz.)

Anthracnose is the most important and widespread decay of papayas on the market. It also affects the leafstalks, blossoms, and very young fruit, causing them to drop. Lesions on the mature papaya usually appear first in or near the fleshy stem. They occur as saucerlike depressions in which for a short period the skin remains normal or is but slightly deeper in color. The spots develop rapidly and may coalesce to cover the entire fruit before it is fully soft. As they enlarge, the lesions become gray to black in the centers and are often covered with a scaly wax composed of dried latex. The decayed tissue is shallow, fairly firm, and may be readily lifted from the surrounding healthy flesh. Under moist conditions pink spore masses are produced from fruiting bodies in the older part of the lesion.

Colletotrichum gloeosporioides, the fungus that causes the disease, also causes anthracnose of citrus fruit (p. 3), avocado (p. 35), and mango (p. 45). Papaya fruits may be infected at any stage in their development and are particularly susceptible as they approach maturity. However, most of the infections do not become visible until the fruit begins to soften.

Bordeaux mixture and other fungicides when applied frequently to the fruits and stems have been found helpful in controlling the disease. Attempts to control the decay by dipping the fruit in fungicidal solutions after harvesting have not been successful.

(See *8*, *103*, *114*, *124*.)

Pineapples

BLACK ROT

(*Ceratostomella paradoxa* (De Seyn.) Dade[12])

OCCURRENCE, SYMPTOMS, AND EFFECTS

Black rot, sometimes called soft rot, water blister, or water rot, is found in all commercial pineapple-growing regions of the world. It attacks all parts of the plant in the field, but it is of chief importance on ripening fruits during transit and marketing periods. Losses of from 3 to 5 percent in stock from Cuba and Puerto Rico because of the decay are ordinarily experienced by dealers on the New York market, and under conditions favorable to the disease, losses in transit may mount to over 25 percent. All commercial varieties are susceptible to the decay. The Red Spanish variety, which constitutes the bulk of the fruit shipped from Cuba and Puerto Rico, is considered one of the most resistant.

On the leaves of the plant in the field the disease appears as small water-soaked spots, which soon dry and become light gray. Planting material may be affected with decay, which begins at the cut made in removing it from the parent plant and develops rapidly through the root-producing area, causing this to disintegrate. Decay of the

[12] Synonym, *Endoconidiophora paradoxa* (De Seyn.) Davidson.

fruit rarely occurs in the field except in pineapples allowed to ripen fully on the plant.

Observations made on the New York city market show that about three-fourths of the decay originates at the base of the fruit, the fungus entering through the cut stem. Most of the remainder of the decay starts at the side of the fruit, although an occasional fruit is invaded through the crown leaves. The decay in the fruit is characterized by a slightly brown water-soaked appearance of the affected tissue. It early becomes very soft and almost liquid with the skin of the fruit forming a brittle shell. If the decay starts at the stem the fungus grows rapidly through the water-conducting strands in the core of the fruit producing no external evidence of decay except for slight softening at the base. In later stages the fruit becomes so completely disintegrated that it yields to the slightest pressure. On broken or otherwise exposed surfaces, decayed tissue becomes covered with a black crust composed of macrospores of the fungus. These also form in the decayed tissue near the core of the fruit, turning it black (pl. 19, *B*). Under warm conditions the vascular strands in the fruit are not disintegrated as rapidly as the remaining tissue, thus giving a decided stringiness to the decayed portion. A sweetish odor of fermentation accompanies the decay.

CAUSAL FACTORS

Black rot is caused by the fungus *Ceratostomella paradoxa*, better known by the name of its imperfect stage, *Thielaviopsis paradoxa* (De Seyn.) Hoehn. This organism is widely distributed in tropical and subtropical countries where it causes important diseases of pineapple, sugarcane, bananas, and other plants. The organism lives and sporulates freely on dead plant parts in the pineapple field; thus abundant inoculum is usually present at harvesttime when the cut made at the base of the fruit as it is removed from the stalk affords a point of easy entry for the fungus. It may enter the fruit through insect punctures or through injuries received during the harvesting, packing, and marketing processes. Much of the rot on the side follows packing bruises that could be reduced by proper sizing of fruit. Although it is probable that the fungus cannot penetrate the uninjured surface of the fruit, very small, invisible cracks between the eyes may allow infection if they come in contact with decayed tissue from a neighboring fruit in a crate.

Moisture conditions in the field at harvest are very important factors in decay development. When high percentages of decay occur in a shipment it is usually found that the fruit was harvested either during or immediately after prolonged rainy periods. In fact, the relation between moisture and the decay is so marked that in some sections it is called water rot.

The fungus develops in the fruit very rapidly at temperatures between 70° and 90° F., but becomes almost quiescent below 50°. It develops more rapidly in ripe than in green fruit. At room temperature, a ripe fruit may become entirely decayed in 3 or 4 days.

CONTROL MEASURES

A control measure frequently used is to expose the cut surface of planting material immediately after removal from the parent plant

to the sun for a day or two. A similar method of control is used with fruits by upending them at the ends of the rows so that the sun may dry the freshly cut stem. This practice cannot be followed in rainy weather, because any extended shower would afford ideal conditions for spread and development of the organism.

Almost complete control of fruit decay starting at the stem can be obtained by treating the cut at the butt end of the fruit within 2 hours after cutting with a solution of benzoic acid in grain alcohol. A solution consisting of 2.5 gm. of benzoic acid in 100 cc. (about 3⅓ ounces per gallon) of 30 percent alcohol affords good control without injury to the tissues of the fruit. The solution is effective through a wide range of concentrations.

Black rot will not develop in fruit refrigerated at 45° F. For fruit in the turning stage of maturity this temperature is satisfactory during transit, but green fruit so handled may retain its acid flavor and fail to color well, so that it is generally shipped at higher temperatures, usually under ventilation.

Care should be exercised throughout the picking, packing, and shipping operations to prevent rough handling. Proper sizing of fruit in order to make a tight pack, but one that will not require forcing of fruit in the crate, will go far toward preventing the decay on the side of the fruit.

(See *22*, *71*, *76*, *86*, *102*, *121*.)

BROWN ROT[13]

(*Penicillium* sp., *Fusarium* sp., and other organisms)

Pineapples are sometimes found on the market showing brown rotten spots from which *Penicillium* sp., *Fusarium* sp., and other organisms can be isolated. The rot can rarely be detected from the outside of the fruit, but upon paring the skin away the small light- to dark-brown, moist, decayed areas can be seen at the center of the fruitlet or eye. Sometimes only the style or central part of the fruitlet is affected. In later stages the decay may progress to the core of the fruit and involve all of the tissue immediately surrounding the floral cavity. It rarely spreads from one fruitlet to another. The prevalence of the decay in ripening fruits from shipments that were mostly sound on arrival in a green condition at the market indicates that the decay develops during transit and marketing.

The two fungi most frequently found associated with the decay are common on rotting vegetation in the field. They are not considered actively pathogenic. Little is known concerning the manner of their entry into the fruit. Some affected fruitlets show abnormally large eye cavities, indicating a structural weakness. Apparently the fungi after gaining entrance into the eye work down the floral parts into the center of the fruitlet. Mealy bugs are often found in the eye cavity of affected fruitlets and may play a part in the introduction of the fungus into the tissue.

The decay is also found as a thin, tan, dry layer, lining deep cracks between fruitlets. These cracks, which are usually accompanied by a

[13] Bratley, C. O., and Wiant, James S. Diseases of fruits and vegetables on the New York market during 1937. U. S. Bur. Plant Indus., Plant Dis. Rptr. Sup. 106 : 74–82. 1938. [Processed.]

gummy exudate, are apparently caused by growing conditions in the field. Before the fruit is picked the organisms enter the cracks, initiate the shallow decay, and produce the typically colored sporulation, pink or white with *Fusarium* and blue green with *Penicillium*.

The only control measures that can be suggested are the maintenance of good growing conditions in the field and control of the insects infesting the plants.

(See *2*, *71*, *102*.)

INTERNAL BREAK-DOWN

A firm, light-brown water soaking of flesh has been observed in shipments of a large-fruited variety of pineapples from Mexico. This break-down appears first in the base of the fruitlets near their attachment to the core in a region an inch or two above the base of the fruit. The water soaking extends outward and upward in the fruit, involving all the tissue in the fruitlet except the ovary and a layer approximately one-fourth inch deep below the skin. Only in advanced stages do the surface of the fruit and the core area become discolored. Hence, in most fruits there may be no external symptoms of the trouble.

The disease is considered to be physiological, since no organism has been found constantly associated with it. Fruits with most extensive break-down are generally overripe; this may indicate that overmaturity is a contributing factor. However, a somewhat similar type of break-down can be produced by heavy waxing of mature green fruits or by holding them in small air-tight containers.

(See *125*.)

Pomegranates

GRAY MOLD ROT

(*Botrytis* sp.)

Pomegranates on the market are occasionally affected with a light-brown, firm decay starting at the calyx. The decayed skin is tough and leathery, but the inner portion of the fruit is dark and disintegrated. Under moist conditions sparse mycelium of a dirty-gray color appears on the decayed area. At various points in the mycelium the typical tan-gray spore-bearing tufts develop.

Control measures for the disease have not been reported. It is probable, however, that the development of the rot in transit and storage can be greatly retarded if the temperature is kept below 45° F. (*43*).

HEART ROT

(Species of *Aspergillus* and *Alternaria*)

Heart rot is found only occasionally in pomegranates on the market, but in some years it is so prevalent in the orchard that heavy culling in the packing house is made necessary. The decay has been found in fruit from various producing districts of the southwestern United States. It rarely appears on the surface of the fruit, but the skin color of affected fruits is slightly abnormal so that experienced graders can eliminate most of it from the pack. Diseased fruits when opened are found to contain a mass of blackened arils (the pulp-bearing seeds) and usually a threadlike black line of decay extending from the calyx into the interior of the fruit (pl. 19, *C*).

Typical symptoms of the decay are produced by each of two different organisms, a species of *Aspergillus* and a species of *Alternaria*. The only control measure that can be suggested is the gathering and destroying of all affected fruits found in the orchard (*65*, *78*).

SUNBURN

Pomegranates at almost any stage after blossoming hang with the blossom end down and thus are exposed at the stem end to injury by the sun. This appears as brown, slightly russeted areas, which sometimes occur on only one side of the fruit but may extend entirely around it (pl. 19, *D*). The injury does not lead to decay and is of importance only as a blemish.

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